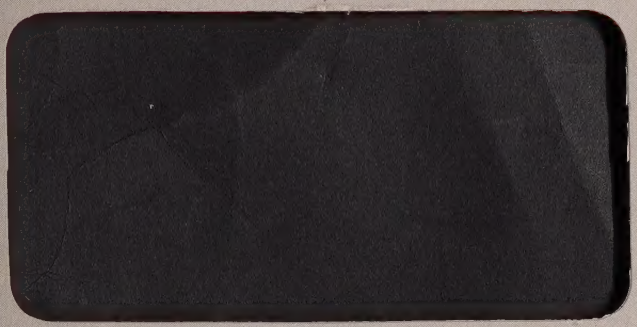
Electronic Services - Los Angeles
M10394X
5426-7

instruction manual

5422/5426



Beckman®

Berkeley Division

BECKMAN/BERKELEY

Model 5426-7

PRESET COUNTER

J. O. # _____

Serial# _____

Berkeley Division
BECKMAN Instruments, Inc.

Richmond 3, California
November 21, 1958

Model 5426-7 Preset Counter

The Beckman/Berkeley Model 5426-7 is a modified Model 5426. Modifications are as follows:

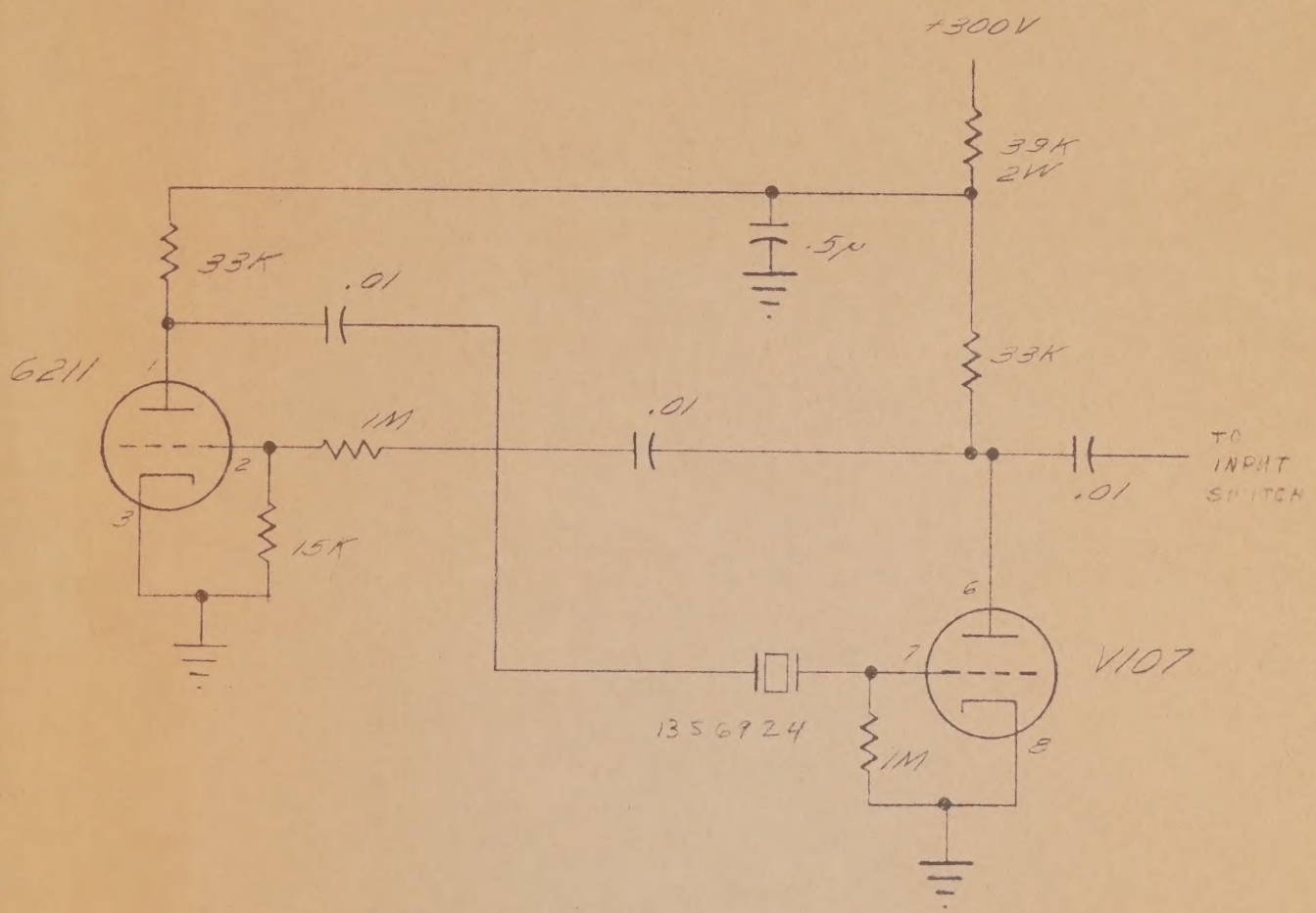
1. A 10 KC crystal controlled source has been added.
2. The relay has been replaced by a millisecond type (Standard "A" modification).
3. Counting stops when preset number is reached.

Since unit is modified to perform a specific function, the Output Selector switch on top of chassis has been locked in the HOLD RELAY position. The FUNCTION switch on the front panel has been locked in the GATE position. The Input switch on top of the chassis should be set to INTERNAL to obtain signal from the self-contained 10 KC source.

Unit will count until preset number is reached, stop counting and give contact closure. Unit will reset when the reset button is depressed.

In all other respects, the standard instruction manual applies.

EFF	REV	ZONE	DESCRIPTION	ECO. No.	DATE	BY	CHK'D	APP.



REF.	STK OR DWG. No.	ITEM AND DESCRIPTION	QTY.

		MATERIAL:	UNLESS SPECIFIED, DIMENSIONS: INCHES DEC. TOLERANCES: .X = ± .050 .XX = ± .020 .XXX = ± .005 ANGULAR = ± ½° SURFACE = 63
5426-7		FINISH:	
MODEL	NEXT ASSY.		
DRAWN [illegible]	DATE 11-21-58	Beckman® / Berkeley *Richmond 3, California*	SCALE:
CHECKED [illegible]	DATE 11/21/58		
CHECKED [illegible]	DATE 11/21/58		
APPROVED	DATE	TITLE: 10 KC OSCILLATOR	DRAWING No. 20345 A 1 — REV.
APPROVED	DATE		

PHASE INVERTER

SCHMITT TRIGGER

GATE AMPLIFIER

INPUT

INTERNAL

EXTERNAL

+320V

140V

40V

-150V

-160V

-300V

-30V

ONE SHOT MULTIVIBRATOR

RELAY/RESET

+300V

-32V

-3.1V

-1.1V

FROM POWER SUPPLY -150V

FROM POWER SUPPLY +100V

FROM POWER SUPPLY 6.3V

NOTE:
1. MODEL 5426 IS MODEL 5422 LESS AY106.
2. MODEL 5424 IS MODEL 5423 LESS AY106 & AY101.
3. MODEL 5423 IS MODEL 5426 LESS (AY106, AY105, AY102 & AY101.
4. MODEL 5422 IS MODEL 5425 LESS (AY106, AY105, AY102 & AY101.
WHENEVER A DCU IS REMOVED, PINS 4 & 7 OF THE EMPTY SOCKETS ARE SHORTED.
* 1. FOR MODIFICATION A OF MODELS 5424, 5425 & 5426:
REPLACE RELAY, K101, WITH WESTERN ELECTRIC L75B.
REPLACE CAPACITOR C109, WITH .02 μf.

NOTE:
UNLESS OTHERWISE SPECIFIED
ALL RESISTORS ½ W.
ALL RESISTORS 10%.
ALL CAPACITORS 500 V.
ALL VOLTAGES MEASURED WITH A SENIOR VOLTOHMIST AND WITH ALL DCUS PRESET AND RESET AT ZERO.
WITH COUNTS TO ON

ZONE	LOT #	REVISIONS					APP'D

DATE	2-3-66	UNLESS SPECIFIED			
DRAWN	KYH	DIMENSIONS, INCHES			
CHECKED		TOLERANCES			
		FRACTIONAL	± 1/64		
		DECIMAL	± .005		
		ANGULAR	± ½°		
APPROVED		SCALE			
		PART OF			

DET. NO.	ITEM	SIZE & MATERIAL OR DWG. NO.	STOCK NO.	QTY.
10	SCHEMATIC			

Berkeley division
BECKMAN INSTRUMENTS INC.

MODEL 5426-7

TITLE PRESET COUNTER SCHEMATIC

DRAWING NO. 2034502

REV. G

INSTRUCTION MANUAL

Models 5422 to 5426
PRESET COUNTERS

Lot [redacted]

Serial No. [redacted]

BERKELEY division of
Beckman Instruments, Inc.

Richmond 3, California
22 October 1956

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Instruments sold by Berkeley Division, Beckman Instruments, Inc., (hereafter called "the Company") are warranted only as stated below.

Subject to the exceptions and upon the conditions specified below, the Company agrees to correct, either by repair, or, at its election, by replacement, any defect of material or workmanship which develops within one year after delivery of the instrument to the original purchaser by the Company or by an authorized representative, provided that investigation and factory inspection by the Company discloses that such defect developed under normal and proper use.

The exceptions and conditions mentioned above are the following:

(a) All instruments claimed defective must be returned to the Company, transportation charges prepaid, and will be returned to the customer with the transportation charges collect.

(b) The Company makes no warranty concerning components or accessories not manufactured by it, such as tubes, fuses, batteries, etc. However, in the event of the failure of any component or accessory not manufactured by the Company, the Company will give reasonable assistance to the purchaser in obtaining from the respective manufacturer whatever adjustment is reasonable in the light of the manufacturer's own warranty.

(c) The Company shall be released from all obligations under its warranty in the event repairs or modifications are made by persons other than its own service personnel or authorized representatives' personnel unless such repairs by others are made with the written consent of the Company.

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(g) This warranty shall be governed by the laws of the State of California.

Claims for damage in shipment should be filed promptly with the transportation company.

All correspondence concerning the instrument should specify the model and serial number. This information appears on the company name plate. Any inquiry concerning details of operation, possible modifications, etc., should be addressed to the Sales Department, Berkeley division of Beckman Instruments, Inc., Richmond 4, California.

REPAIR SERVICE

Experienced service personnel and special test equipment are available at the factory to perform any necessary repairs. Every effort will be made to expedite the repair of instruments returned for servicing. Repair work will be performed only upon receipt of a written purchase order or authorization. Instruments to be repaired should be addressed to SERVICE AND REPAIR DEPARTMENT with transportation charges prepaid. Repaired instruments will be returned to the purchaser with transportation charges collect.

Berkeley reserves the right to make changes in design at any time without incurring any obligation to modify equipment previously purchased to conform to subsequent design changes.

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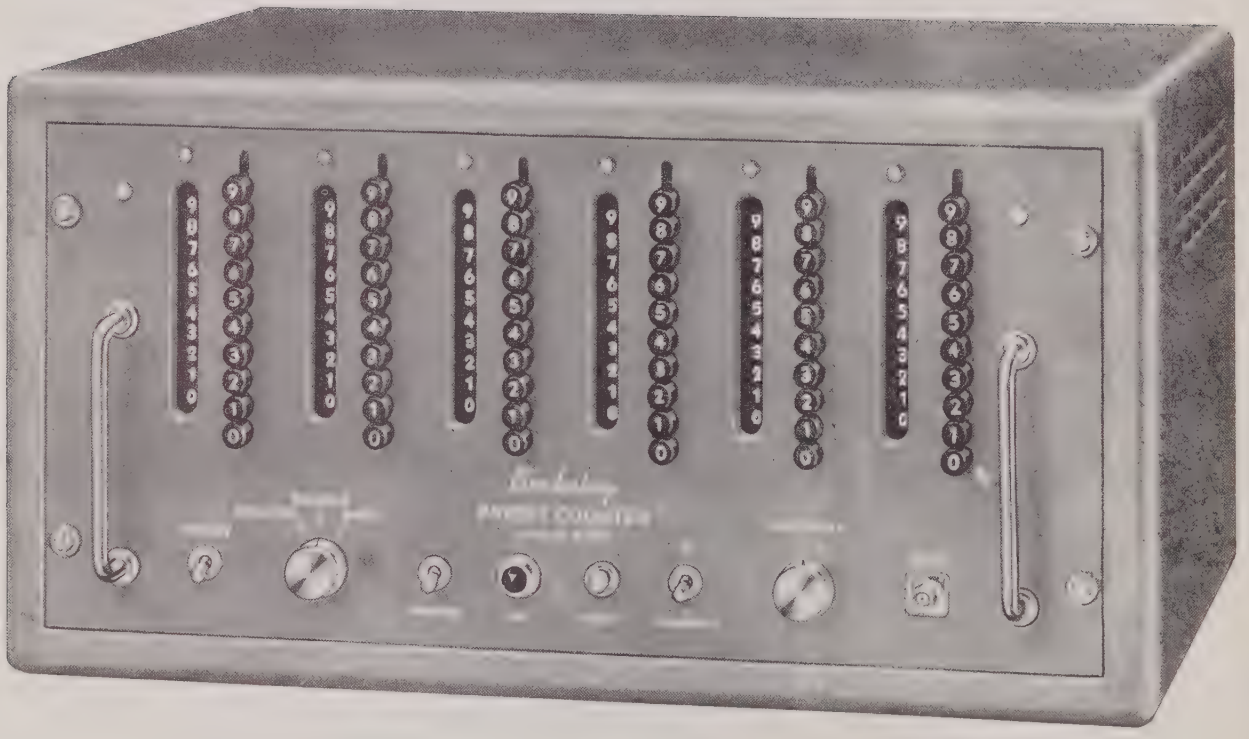


Figure 1. Berkeley Model 5426
Preset Counter.

Section 1

INTRODUCTION

The Berkeley Preset Counter is a high speed electronic counter from which output information may be obtained at any count up to the maximum capacity of the unit. Any discrete series of physical events that can be represented by a fluctuating voltage can be counted. Various transducers such as photocells, magnetic pickups, switches, or other devices may be used to provide an output for counter operation.

Simplicity and flexibility of design make this an ideal instrument for production control. Many processes may be automatically controlled by the output signal. For instance, a variable delay or an alarm at a preset count can be obtained. Or with a constant input frequency, the instrument functions as a pulse source of variable repetion rate whose period is a multiple of the input period.

Specifications

Counting Capacity:	5422, 1-100; 5423, 1-1000; 5424, 1-10, 000; 5425, 1-100, 000; 5426, 1-1, 000, 000.
Frequency of Count:	0 to 40,000 cps.
Input Sensitivity:	± 1 volt peak with respect to ground, 2 microseconds duration.
Impedance:	1 megohm shunted by 40 $\mu\mu$f, approximately.
Power Requirements:	Models 5424, 5425, 5426: 117 volts a-c ± 10%, 180 watts. Models 5422, 5423: 117 volts a-c ± 10%, 90 watts.
Accessory Socket:	10-pin connector.
Dimensions:	20-3/4" wide x 10-1/2" high x 15" deep (5424, 5425, 5426) 16-3/4" wide x 10-1/4" high x 13" deep (5422, 5423)
Weight:	60 lbs. (5424, 5425, 5426); 40 lbs (5422, 5423).

Section 2
OPERATION

Installation

The Preset Counter requires no special installation procedure. It may be operated in any location having adequate ventilation. The instrument is designed to operate from an a-c power source of 117 volts ± 10%, 50 to 60 cps. Models 5422 and 5423 consume 90 watts power, and Models 5424, 5425, 5426, 180 watts.

Operation

According to the position of a front panel switch, the Preset Counter will perform one of three functions. In the COUNTER position, the instrument functions as a straightforward electronic counter. Output information is obtained each time the full capacity of the unit is reached. In the RECYCLE position, the unit will count to the preset number, provide an output pulse, reset, and indefinitely repeat the cycle without losing a count. In the GATE position, the instrument counts until the preset number is reached; then the input to the counting units is gated off. This number is displayed until it is cleared by the RESET button or an external pulse.

Two types of output are available, a positive pulse rising from about -25 to +30 volts and a relay break or closure (two DPDT contacts). Pulse output is obtained at Pin H of J103 and the relay contacts are available at J104 a 10-pin connector. The OUTPUT SELECTOR switch (S105) on the top of the chassis determines which output is available. In the PULSE position a pulse 45 volts high and 12 μseconds long is generated. In the PULSE-RELAY position a pulse of the same amplitude is produced whose duration may be varied from 0.02 seconds to 0.3 seconds by adjusting the PULSE WIDTH control. The normally energized relay is de-energized for the duration of this output pulse. The HOLD-RELAY position may be used only when the function switch is at GATE. Under these conditions the instrument counts until the preset number is reached, at which time the output relay is de-energized and the output at Pin H of J103 rises from -25 to +20 volts. However, the input to the DCU's is not gated off. These conditions are held until the instrument is reset.

To put the Preset Counter in operation, connect the power cable and turn on the POWER switch. Put the POLARITY switch in the position corresponding to the polarity of the input to be used. Select the proper position of the function switch, COUNTER, RECYCLE or GATE. A cable with a BNC type male connector is provided for use with the INPUT connector. The other end of the cable can be connected directly to the signal to be counted, provided its DC level is at ground potential; otherwise a suitable blocking capacitor must be used. Turn on the COUNT switch and

adjust the SENSITIVITY control to a point just beyond the point where the instrument will properly count the input pulses.

To preset the counter, push the desired button in each column of digits. These buttons are clearly numbered to correspond to the number on the lucite panel of the Decimal Counting Unit to which they are attached.

Proper Operation of Standard Relay

Contacts are rated at 5 amperes; 115 volts, 60 cycles, non-inductive load. Reliable operation of this relay may be expected up to a rate of 25 operations per second. To reduce arcing across the relay contacts and eliminate stray count, an absorption circuit formed by a series connected resistor and capacitor shunted across the contacts may be necessary. Place this circuit immediately adjacent to the relay terminals wherever possible.

Component values, a function of the open circuit voltage across the contacts and the steady current of the external load, should be determined empirically. The capacitor should be large enough to minimize arcing when the contacts open, but not so large that contacts are latched when another relay is energized. The resistor should be just sufficient to limit the capacitor discharge current during closure and minimize contact pitting.

Three specific applications are listed below to indicate orders of magnitude for the components. Two different networks are listed for each application.

	#1	#2
Electro-Mechanical Register, 117 volts a-c, 0.18 amp	0.02 μfd 100 Ω	0.1 μfd 100 Ω
Relay, 117 volts a-c, 0.06 amp	0.02 μfd 100 Ω	0.07 μfd 270 Ω
Motor Control Relay, 117 volts a-c, 0.25 amp	0.8 μfd 100 Ω	1.2 μfd 100 Ω

The internal connections of the standard relay are diagramed in Figure 10.

Table 1

CONTROL AND CONNECTOR FUNCTIONS

Control or Connector	Detail No.	Component	Function
		FRONT PANEL	
COUNT	S103	DPDT toggle	Allows instrument to count when ON. When OFF, instrument will never count.
COUNTER-RECYCLE-GATE	S104	3-pole 3-position rotary switch	Selects the desired function.
POWER	S106	DPST toggle switch	Line voltage is connected to instrument when ON, as indicated by green pilot light.
RESET	S102	DPST pushbutton switch, NC	Resets all the DCU's.
POLARITY	S101	SPDT toggle switch	Selects the desired polarity.
SENSITIVITY	R101	1M, 2 watt potentiometer	Makes instrument less sensitive by attenuating the input amplitudes.
INPUT	J101	Type BNC connector UG-290/U	Connector for input source.

Control or Connector	Detail No.	Component	Function
		CHASSIS	
OUTPUT SELECTOR	S105	3-pole 3-position rotary switch	Connects relay circuitry for proper operation.
ACCESSORY	J103	AN3 102-18-1S	Ten-pin connector with the following connections for operating external apparatus: Pin A: Ground B: C: -150v. regulated D: External reset. Requires a pulse of +130 v., 15 μsec. duration, 3 μsec. rise time. E: Ground, filament. F: B+, 300v. regulated. G: H: Output voltage swings between -35 and +10v., 3 μsec. rise time, variable duration. I: Filament, 6.3 v. AC J: +100 v.
B+ ADJ.	R149	250K or 100K potentiometer	Adjusts B+ value.
FAN	S107	DPST toggle switch	Connects fan to power when ON.
117 VAC	J102	Recessed two-pronged plug.	Receptacle for power cord.
RELAY CONTACTS	J104	AN3 102A-18-1P	Connects to relay contacts
DIGITAL SCANNER (optional)	J105	AN3 102A-18-12P	Connects to Digital Scanner
PULSE WIDTH	R157	Potentiometer 5 M, 2 watt	Adjusts duration of output pulse and relay break or closure.

Section 3
THEORY OF OPERATION

Design

Basically, the Preset Counter consists of an input circuit, an electronic gate, a system of cascaded presettable Decimal Counting Units, and an output circuit. The variation in voltage is applied to the input circuit, amplified, shaped, and sent to an electronic gate. When this gate is opened, the incoming count is passed to the first of the cascaded DCU's. At the preset number, an output pulse from the DCU coincidence system initiates various electronic operations, e g., resetting the DCU's actuating a relay circuit, transmitting an output pulse, and /or closing an electronic gate.

Input Circuit

A phase inverter (V101) and Schmitt Trigger (V102) make up the direct-coupled amplifier which amplifies and shapes the input pulses. The phase inverter amplifies and, in conjunction with the polarity switch, sends positive pulses to the trigger circuit which provides voltage discrimination and a standard output.

Equal voltages on both plates of the phase inverter are maintained by a cathode adjustment (see Figure 2), resulting in an extremely stable circuit which requires no specially selected tubes. Balancing the voltages 5 to 8 volts below the upper trigger level of 143 volts assures the triggering of the Schmitt Trigger with a rising voltage without respect to the polarity of the input pulse. Properly adjusted, the plate voltages will stay indefinitely within a volt or two of each other.

The plates of the phase inverters are alternately d-c coupled to the input grid of the Schmitt Trigger through the POLARITY switch (see Figure 2). The triggering, detriggering, hysteresis voltages are 143, 140. 5 and 2. 5, respectively. An output swing of 75 volts is obtained across the 10K resistor with rise and fall times of about 1. 5 microseconds.

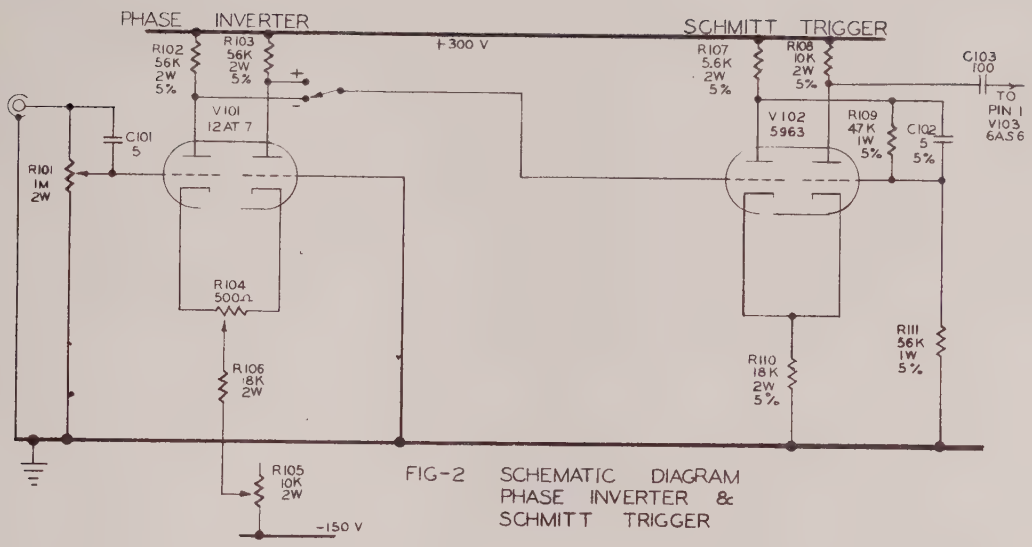


FIG-2 SCHEMATIC DIAGRAM PHASE INVERTER & SCHMITT TRIGGER

Electronic Gate

The output of the trigger circuit is R-C coupled to the control grid of the 6AS6 (V103), a dual-control pentode biased beyond cut-off. A 100 volt negative output pulse from this stage drives the first DCU. With the function switch set at GATE, the gate closes and cuts off the drive to the first DCU at the preset count because of the negative bias on the suppressor grid which prevents conduction regardless of the control grid voltage. The preset count is displayed until either the RESET button is pressed or a pulse of at least 125 volts amplitude, 3 μsecs. rise time, and 15 μsecs. duration is applied at pin L of the accessory socket. Set at RECYCLE or COUNTER, the suppressor grid is grounded, thereby holding the electronic gate open.

The COUNT switch is wired in series with the suppressor grid. In the OFF position a negative voltage connected to the suppressor grid keeps the tube below cut-off. In the ON position, the gating action of the suppressor grid depends on the function of the instrument.

Decimal Counting Units

Two to six Model 730A DCU's are cascaded to give the desired capacity. To complete the coincidence system, all of the plates of the 5964 tubes are connected through R117 (47K);to the 300 volt supply. Prior to the occurrence of the preset count, the common plate voltage is less than +50 volts. When the preset count is reached, all of the 5964 tubes are cut-off and the plate voltage rises to +260 volts in 15 microseconds.

The Model 730 DCU is discussed in Appendix A.

Output Circuit

The positive transient from the coincidence circuit is applied to the grid of one-half of V104 (5963), which functions as an inverter-amplifier. The ratio of the resistor-divider (R119, R120 is chosen so that when the coincidence plate voltage is low, the triode is cut-off. Conversely, with a high coincidence plate voltage, the triode conducts, producing a negative transient at the triode plate which will actuate an electronic gate, energize an electronic relay circuit, reset the DCU's, and/or supply an output pulse for some other purpose.

For the GATE function only, the voltage output of the inverter-amplifier is divided and applied to the suppressor grid of the gate tube, if the INPUT SELECTOR is at PULSE or PULSE RELAY. Cutting off the inverter-amplifier opens the gate, In the HOLD-RELAY position the inverter-amplifier does not affect the gate.

In either the GATE or RECYCLE position, the output of the inverter-amplffker drives a one-shot multivibrator (V105). In the COUNTER position, the multivibrator is driven by the output of the last DCU through an isolation amplifier, V104B.

For a fail-safe scheme, the relay is normally energized before the preset count is reached. A power failure will then release the relay. The multivibrator supplies the output pulses, and in the PULSE-RELAY and HOLD-RELAY positions deenergizes the relay for a period dependent on the PULSE WIDTH setting. The relay should be cut out of operation when the recycling rate exceeds 25 per second to preclude erroneous recycling at high frequencies.

To reset the DCU's with the instrument in the RECYCLE position, the output of the multivibrator (V105) drives a cathode follower, one-half of V106. DCU's are reset in about 15 μseconds, a period short enough to allow the instrument to reset and resume counting without missing a count.

The cathode follower can be used to electronically reset the Counter in the GATE position by supplying a positive pulse of 125 volts amplitude, 3 microseconds rise time and at least 15 microseconds duration to pin D of the accessory socket.

Power Supply

A conventional power supply provides a regulated B+ of 300 volts and an OA2 glow discharge diode stabilizes the bias supply at -150 volts. B+ ripple is about 0.1 volt peak to peak.

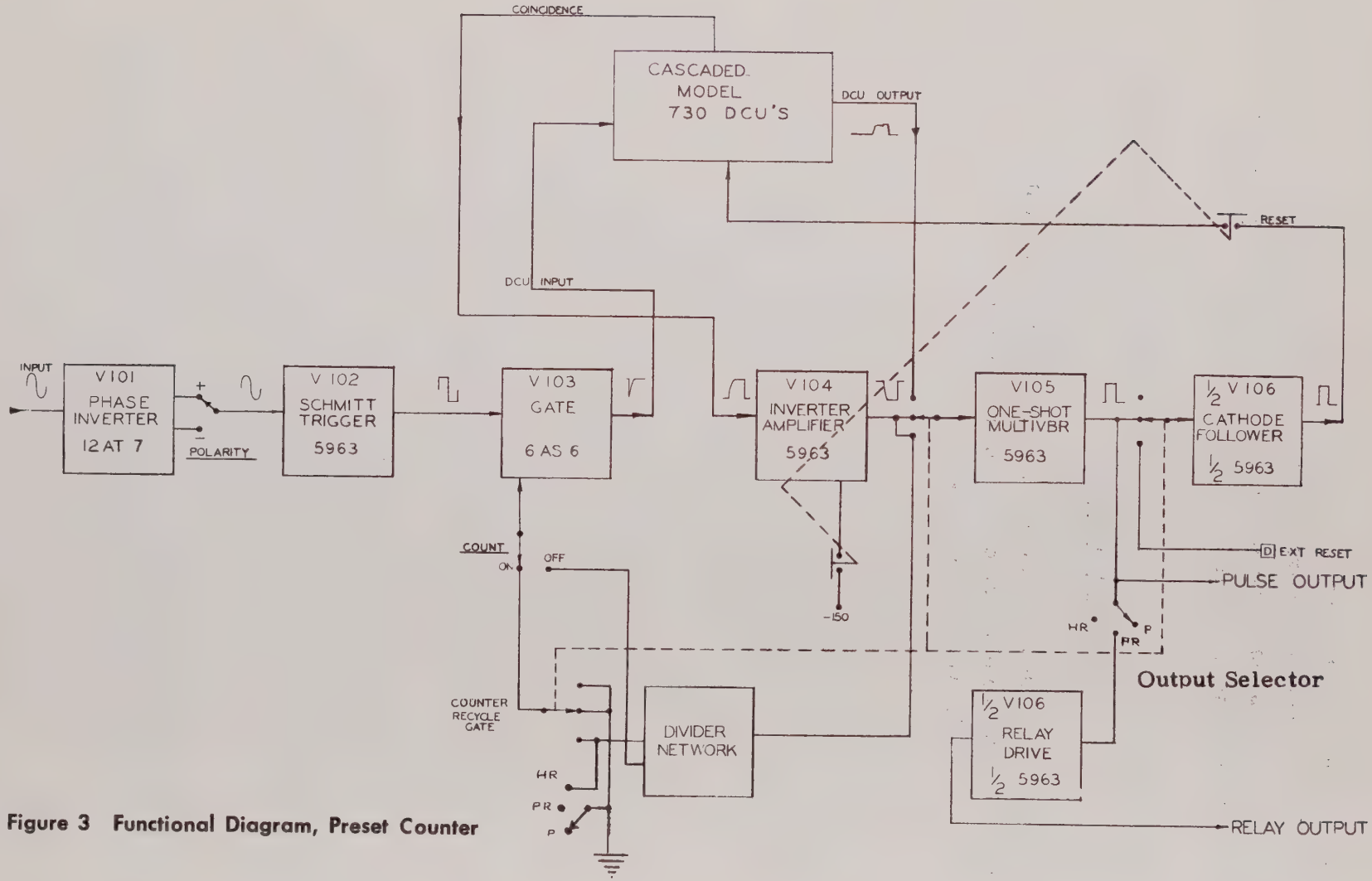


Figure 3 Functional Diagram, Preset Counter

Section 4
MAINTENANCE

When the instrument requires servicing, a qualified technician who has both a high grade oscilloscope and a vacuum tube voltmeter at hand should be employed. Refer to the functional and circuit diagrams, maintenance guide chart and oscilloscope waveforms for aid in servicing and understanding the instrument. Faster and better maintenance will result if the technician thoroughly acquaints himself with the material presented in this section before servicing the instrument.

In the maintanance guide chart, some of the more common faults are listed. A "dependence" type of structure has been used in preparing this chart. A function of the instrument will not operate properly unless the factors listed below it in the chart operate properly, that is, the chart should be read from the bottom up. For example, the unit will not function in the GATE position unless it first functions in the COUNTER position. However, the unit will function in the COUNTER position even if trouble exists in the GATE or RECYCLE circuitry. Again, the inverter amplifier (1/2 V104) serves no purpose unless the coincidence circuit (below it on the chart) is in good order.

Consequently, in servicing the instrument, the technician should check the operation against the chart to determine the approximate region of trouble. Specifically, the technician might use the following procedure: Place the instrument in the COUNTER position and follow the operating instructions described in Section 3, noting the DCUaction - a good check can be made by observing the output waveforms of the DCU's at pin 4 on their octal plugs.

If the ;DCU's count improperly, the fault lies below the dotted line in the maintenance chart. Check the power supply, input source and circuitry, and DCU's. If the DCU's scale correctly, the fault lies above the dotted line in the chart and the next step is to check the unit in the GATE function. If GATE operation is correct, then check the RECYCLE function. If not, check circuitry controlling the GATE operation.

The following paragraphs discuss servicing techniques pertinent to the COUNTER, GATE and RECYCLE functions. In every case, the power supply should be checked before extensive servicing of the remaining

circuitry is undertaken. If the ripple on the B+ bus bar exceeds two-tenths of a volt peak-to-peak, generally the 6AU6 control tube (V109) and/or the OA2 tube (V110) should be replaced. If there is no voltage at all, V108 (6AS7G or 6080) and/or the 5U4G (V107) rectifier tube should be replaced.

Counter Function

First check the characteristics of the waveform applied to the instrument. Then check the input of the first DCU (AY101) for pulses at pin 7. If pulses are not present, isolate the defective stage by tracing the circuit back to the point where pulses appear. Waveforms at the pertinent points of the circuitry should be compared with those in Figure 4, particularly noting the amplitudes, rise times, and durations. If the correct input pulse is present at the first DCU, check the output of the remaining DCU's for correct scaling with an oscilloscope. If necessary, analyze the DCU circuitry (see Appendix A).

The unit may respond only to pulses of one polarity if the plates of V101 (12AT7) are unbalanced or cathode emission is low. This is especially the case for small amplitude input pulses. Unbalanced plates can be equalized by varying R104. If the instrument counts intermittently, one or more of the following factors is usually the cause: the plates of V101 are unbalanced, V101 is bad, or the input amplitude pulses are low.

When the plates of V101 have been balanced, set the plate voltage level 5 to 8 volts below the trigger level of the Schmitt circuit (V102) by varying R105. Rebalance the plates of V101 if necessary. The trigger level of the Schmitt circuit may be determined by varying R104 back and forth slowly with no input until the first DCU (AY101) indicates a count, and reading the voltage on pin 2 of V102 when the count is registered.

Gate Function

Proper operation in the COUNTER position is necessary but not sufficient to operation in the GATE position. The switch stacks, coincidence circuit and inverter amplifier (1/2 V104) must also be in good order.

If all the banks are preset to zero, or if no number is preset, the instrument will not count in the GATE position. Such a condition means

That coincidence has been reached for a zero count, and the input gate to the DCU's is closed.

Erratic operation on the part of any individual coincidence circuit will disable the whole system. Failure is evident when the unit stops at the wrong count or counts past the preset count.

To locate a DCU with a faulty coincidence circuit, separately disconnect the coincidence circuit of each DCU from the system by removing its two 5964 tubes until the remaining DCU's give coincidence at the preset count. Start with the left hand DCU, the slowest counting one, and work towards the right. The last DCU disconnected is the one at fault.

To check the switch stacks and 5964 tubes of the bad DCU, refer to Appendix A. Replace the DCU after servicing and check the instrument.

Replace the other DCU's in reverse order (i. e., the last removed first) and check the circuit for proper operation. If trouble develops, the last DCU replaced is at fault.

Where the unit stops at a number other than the preset count, it is quicker to examine each DCU which registers a digit other than the preset digit and then replace them in the instrument and test GATE operation.

DCU's with faulty coincidence circuits can also be found with the instrument in the RECYCLE position in the same manner. Remove the DCU's from the circuit until the circuit functions properly. However, troubles in the reset circuitry and the supply voltage system invalidate this method. If the DCU coincidence circuits are in good order, check the plate voltages of the 5964 common plates (pin 10, each DCU) at coincidence. It should rise to about 40 volts less than the B+. Observe this voltage when a low input frequency is applied to the instrument. If this voltage rises when the preset count is reached and the unit continues to count, the inverter-amplifier (1/2 V104), the resistor divider network (R119, R120) and their associated voltages must be checked.

The RESET switch is designed to prevent spurious triggering of the one-shot multivibrator by the voltage changes which occur during the reset action. One half of the switch (S102B) opens to reset the DCU's. The other half (S102A) opens to place a negative blocking voltage of about 30 volts on the input grid of the multivibrator while the DCU's are resetting. When the RESET button is depressed and released this half (S102A) opens before and closes after S102B so that the multivibrator is blocked all the while the RESET action is taking place.

Opening S102A also places a negative blocking voltage on the grid of the gate tube (V103) when the instrument is in the GATE position. This action insures that no pulses will be counted while the multivibrator is blocked and unable to halt counting should a preset count be reached.

Recycle Operation

Primarly, proper operation of the RECYCLE function depends on proper GATE operation, which means generation of a coincidence pulse at the preset count. This pulse through the inverter-amplifier drives the one-shot multivibrator and furnishes an output pulse to reset the DCU's. Correct recycling also depends on the cathode-follower as well as the output characteristics of the one-shot multivibrator. Hence, if the unit operates correctly in the GATE position, but fails in the RECYCLE position, the reset circuitry is at fault or the B+ voltage is at an extreme value.

To check the circuit, compare the waveforms for V105 and V106 with those in Figure 4 C, particularly noting the rise times, amplitudes, and durations. All waveforms were photographed with the instrument in the RECYCLE position and 40 kc input. The oscilloscope sweep times are given for 10 centimeters. Check the tube voltages at various points.

If the reset circuitry is in good order, then the B+ value must be checked. For a given bias supply voltage, there is at least a 30 volt B+ range over which the instrument will recycle properly. The B+ range for the RECYCLE function limits the overall range of the instrument. At the upper limit, the instrument will not function for certain preset counts and at the lower limit the sensitivity falls below the required ±1 volt. The B+ is factory adjusted for about 300 volts, the approximate center of the range.

With an input frequency of 20 kc or above, and an oscilloscope tied to pin 3 of V106, the effect of different B+ values on the recycling operation for different preset counts can be observed. Set the B+ at 340 volts and observe the periods of the waveforms on the oscilloscope for preset counts of 1 to 100. Lower the B+ value if necessary until all counts recycle properly. This procedure gives the upper limit.

with an input source of one volt peak amplitude, lower the B+ until DCU's stop counting or recycling fails. With this lower limit, the B+ range is known. A value about 15 volts below the upper limit is a good arbitrary setting.

MODIFICATION A

Modification A adds a high-speed mercury-contact relay for operations up to 100 cycles per second. Accordingly, the PULSE WIDTH adjustment of both channels has been changed to provide a 100 milliseconds range.

A Western Electric 275B mercury contact relay has been added. The maximum operating speed is determined by the number of ampere-turns in excess of those necessary to operate the relay. One hundred and eighty ampere turns are required to operate the relay, leaving an excess of 200 in this application.

Total current through the four stationary front and back contacts should not exceed 5 amperes rms on a continuous basis. In addition, for long service life, the following ratings apply:

1. For any single contact within the relay the current immediately prior to opening should not exceed 5 amperes.

2. The voltage across the contacts immediately prior to closing should not exceed 500 volts.

3. The product of current at opening and voltage at closing as described above should not exceed 250 volt-amperes. This condition defines the current-voltage relations permissible for currents less than 5 amperes in the voltage range from 50 to 500 volts.

Absorption Circuit - For the absorption circuit, the preferred values of R can C can be determined by the following equations, except where indicated below:

$$C = \frac{I^2}{10} \quad \text{microfarads} \qquad \text{(A)}$$

$$R = \frac{E}{10I\ (1+ 50/E)} \qquad \text{(B)}$$

Where I = load current in amperes immediately prior to opening of cantacts.
E = source voltage immediately prior to closing of contacts.

The calculated value of C is required in all cases, if E is less than 50 volts, and I less than 2.5 amperes, R may be omitted. For all other conditions, R shall be determined by equation (B) but must not be less than 0.5 ohms.

For E up to 70 volts, R may be three times value in (B)
For E at 100 volts, R shall be within ± 50% of value in (B)
For E at 150 volts, R shall be within ± 10% of value in (B)
For E greater than 150 volts, equation (B) should be followed closely.

Load and Wiring Protection. - The "break" action of this relay is extremely rapid, resulting in very large peak voltages across the load. For protection of the load and circuit wiring, these peak voltages can be reduced to safe levels by increasing C in equation (A) above the minimum value required for contact protection. The appropriate value can be determined by measuring peak values within the first few milliseconds after break of the contacts.

Characteristically, when these relays are operated at rates of less than one per second, all four stationary contacts and the armature may be electrically connected during the transfer of the armature from one pair of stationary contacts to the other. This "bridging" occurs, it should not last more than a millisecond. If the application of this relay involves a source of power across the front and back contacts, fulfill the contact protection requirments and do not exceed current ratings. In some cases, a current limiting impedance in the power circuit may be required.

Temperature Limits - The maximum ambient temperature is determined by the melting point of the compound used in the relay assembly. At an ambient of 100°F, the total power dissipation in the operating coil and switch assembly must not exceed 2 watts continuously. At higher ambient temperatures, operation is permissible with lower power dissipation in the relay. The steady state temperature rise is approximately 35°F per watt of total dissipation in the operation coil and switch assembly. An internal temperature of 170°F must not be exceeded.

Mounting Position - Optimum performance is obtained when this relay is operated in a vertical position. Somewhat decreased performance is obtained for operation at small angles off the vertical position. The drive on the operating winding as well as the departure of the relay mounting position from a true vertical position affect the "bridging-transfer" time of this relay. Mounted at an angle other than vertical, the departure should not exceed 30 degrees from the vertical. Under such conditions and for operating rates of less than one per second, any "bridging" should not last more than one millisecond.

CONNECTION DIAGRAM

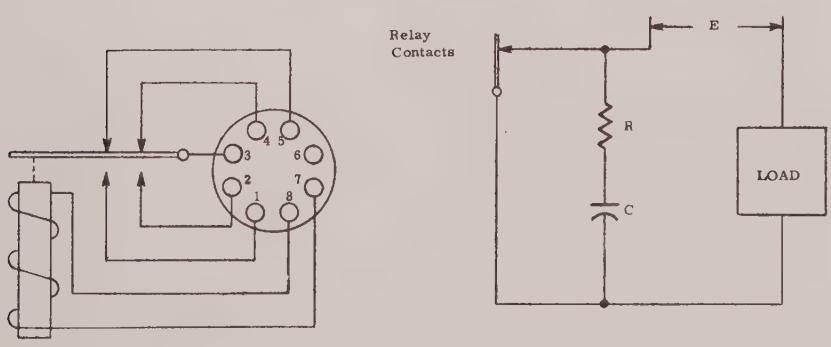


Table 2

PRESET COUNTER MAINTENANCE GUIDE CHART

Function	Circuit Element	Factors
RECYCLE	Cathode follower (1/2 V106)	
	One-shot multivibrator (V105)	Duration, 14 μsec. Rise time, 3 μsec
	Relay (1/2 V106)	Should be OFF when recycling faster than 10 cps.
GATE	Inverter-amplifier (V104)	Low emission
	Coincidence circuit of DCU	DCU circuitry (see 730A Manual Bad 5964 tubes
	Switch stacks of DCU	All zero's preset, or none preset Not making contact Not breaking contact One button not clearing others
COUNTER	Decimal Counting Units	See DCU Manual
	Gate tube (V103)	Count switch OFF unknowingly
	Trigger circuit (V102)	Rise time, 1.5 μsec Output, 75v.
	Phase inverter (V101)	Low emission Wrong plate level Unbalanced plates (R104) Wrong POLARITY switch selection Wrong input characteristics

POWER	Control tube (V109)	Wrong B+value (R149)
	Series tube (V108)	
	Filter network (L101, C115, C120)	
	Regulator tube (V110)	
	Rectifier (V107, CR101)	
	Transformer (T101)	

Section 5
REPLACEMENT PARTS LIST

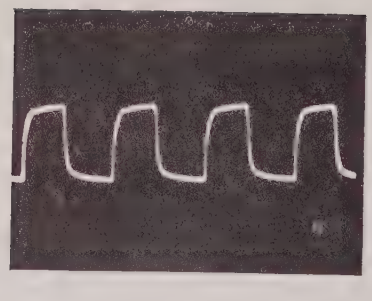
List of Non-Standard Components

Detail No.	Stock No.	Item	Mfr. & No.	Description
K101	16-3449	Realy	Potter Brumfield MH 4412	
K101	16-3454	Relay	Western Electric M275B	For modification A
I101	21-1677	Pilot lamp	GE #47	Indicator lamp
B201	9-3390	Fan motor	General Industries	
	24-3445	Fan blade	A-5-CW	YAB 328
J101	17-0349	Connector	IPC 2700	Coaxial
J103	17-1665	Receptacle	Cannon AN3102-A-18-1S	10 No. 16 inserts
J104	17-1665	Receptacle	Cannon AN3102-A-18-1S	10 No. 16 inserts
S101	12-1641	Switch	Cutler-Hammer 828K14	SPDT toggle
S102	12-1614	Switch	Switchcraft 7005	NC pushbutton, DPST
S103		Same as S101		
S104		Switch	Centralab 2507	Rotary
S105	12-1642	Switch	Cutler-Hammer 8370K8	DPST toggle
S106		Same as S105		
S107	12-1643	Switch	Cutler-Hammer 8280K15	SPST toggle

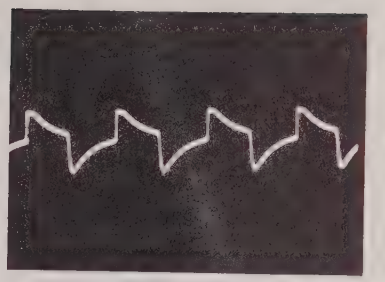
Detail No.	Stock No.	Item	Mfr. & No.	Description
CR101	8-1699A	Rectifier	Radio Receptor Corp.	6M1
CR102		Same as CR101		
		FOR MODELS 5424, 5425, 5426		
T101	6-2164	Transformer	Electro E6867	900 V CT at 200 ma; 200 V tap at 20 ma; 6.3 V at 15 A 5V at 3 A
L101	3-2458	Choke	United Transformer CG-40	10 H, 200 ma
		FOR MODELS 5422, 5423		
T101	6-2376	Transformer	Triad 7115	750 V Ct at 80 ma; 145 V tap at 20 ma; 12.6 V at 6 A; 5 V at 3 A

Tube List

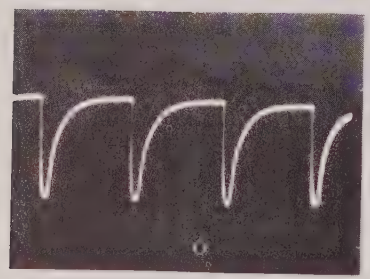
Tube	No. Required Per Unit
5U4G	1(V107)
6AS6	1 (V103)
6080	1 (V108)
6AU6	1 (V100)
12AT7	1 (V101)
5963	4 (V102, V104, V105, V106)
OA2	1 (V110)



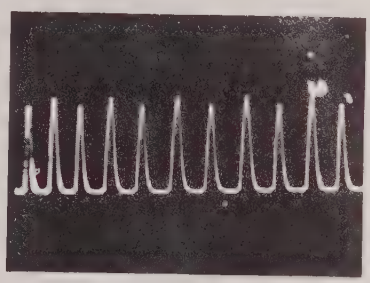
A. Schmitt Trigger output at pin 6 of V102, peak to peak amplitude 75 volts, rise time 1.5 μsec, and oscilloscope sweep time 100 μsecs.



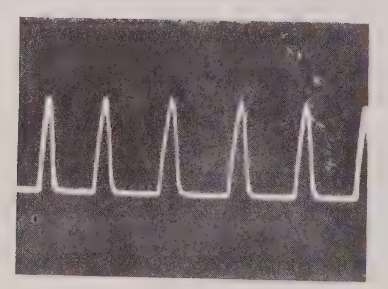
B. Gate tube input at pin 1 of V103. Positive peaks are slightly clipped when the tube draws grid current. Peak-to-peak amplitude 75 volts oscilloscope sweep time 100 μsecs.



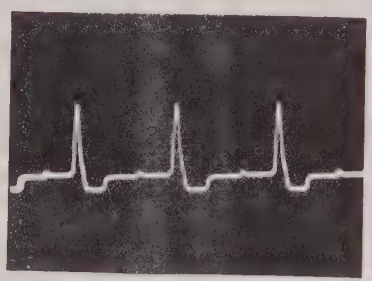
C. Gate tube output at pin 5 of V103. The amplitude of the negative pulses is 100 volts and the oscilloscope sweep time 100 μsecs.



D. Coincidence system output at pin 10 of any Model 730 DCU for a preset count of 1 (1 in the units bank, AY101, with all other DCU's preset to 0). The frequency of this train of pulses is 40 kc, which is equal to the input frequency. Correspondingly, the period is 25 μsecs. When recycling, the amplitude of the coincidence pulses is about 120 volts. Oscilloscope sweep time, 250 μsecs.

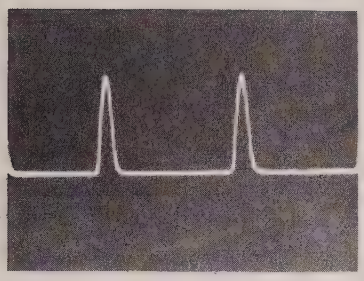


E. Coincidence system output at pin 10 of any DCU for a preset count of 2. Amplitude of 120 volts and period of the waveform 50 μsecs, twice that of input waves. Oscilloscope sweep time, 250 μsecs.

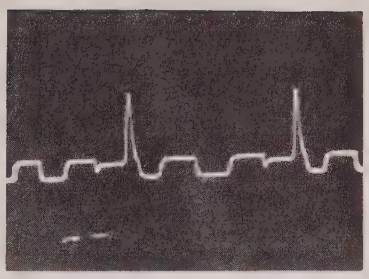


F. Coincidence system output at pin 10 of any DCU for a preset count of 3. Amplitude, 120 volts and period, 75 μsecs, three times that of input waves. Oscilloscope sweep time, 250 μsecs.

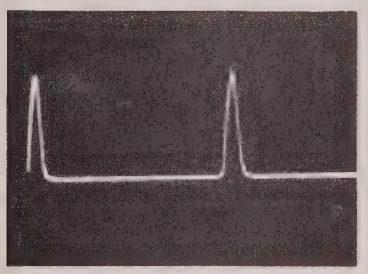
FIGURE 4A - PRESET COUNTER WAVEFORMS



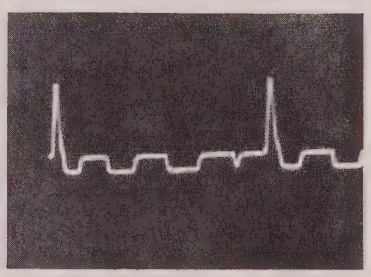
G. Coincidence system output at pin 10 of any DCU for a preset count of 4. Amplitude 120 volts, period is 100 μsecs, four times that of input waves. Oscilloscope sweep time 250 μsecs.



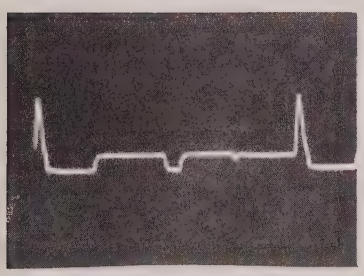
H. Coincidence system output at pin 10 of any DCU for a preset count of 5. Amplitude, 120 volts, period 125 μsecs, five times that of input waves. Oscilloscope sweep time 250 μsecs.



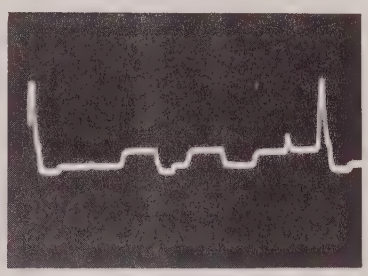
I. Coincidence system output at pin 10 of any DCU for a preset count of 6. Amplitude, 120 volts, period 150 μsecs, six times that of input waves. Oscilloscope sweep time 250 μsecs.



J. Coincidence system output at pin 10 of any DCU for a preset count of 7. Amplitude, 120 volts, period is 175 μsecs, seven times that of input waves. Oscilloscope sweep time 250 μsecs.

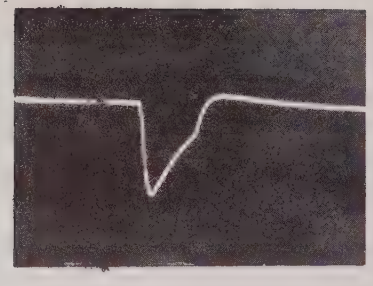


K. Coincidence system output at pin 10 of any DCU for a preset count of 8. Amplitude, 120 volts, period of 200 μsecs, eight times that of input waves. Oscilloscope sweep time 250 μsecs.

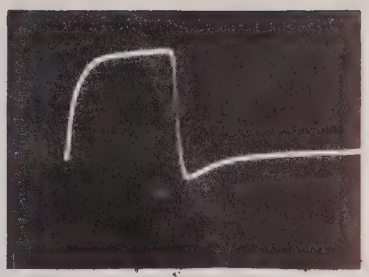


L. Coincidence system output at pin 10 of any DCU for a preset count of 9. Amplitude 120 volts, period 225 μsecs, nine times that of input waves. Oscilloscope sweep time 250 μsecs.

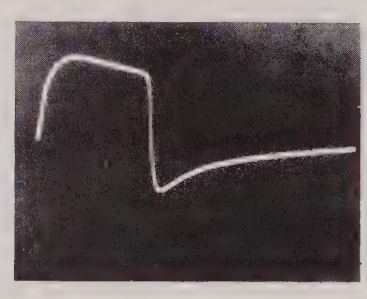
FIGURE 4B - PRESET COUNTER WAVEFORMS



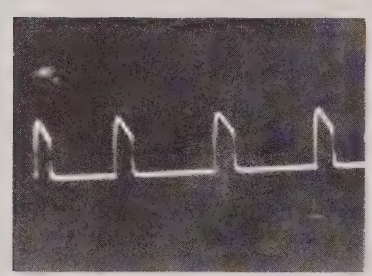
M. Inverter amplifier output at pin 6 of V104. Voltage level drops from 275 to 150 volts at coincidence. 20 μsecs later, the original voltage level is restored. Oscilloscope sweep time 100 μsecs.



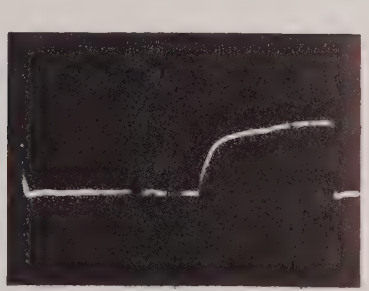
N. One-shot multivibrator output at pin 1 of V105. Rise time, 3 μsecs, duration of 14 μsecs and an amplitude of 125 volts. Oscilloscope sweep time, 50 μsecs. With the relay in the circuit, the duration is 1/30th of a second



O. Cathode-follower input at pin 2 of V106. Oscilloscope sweep time, 50 μsecs.

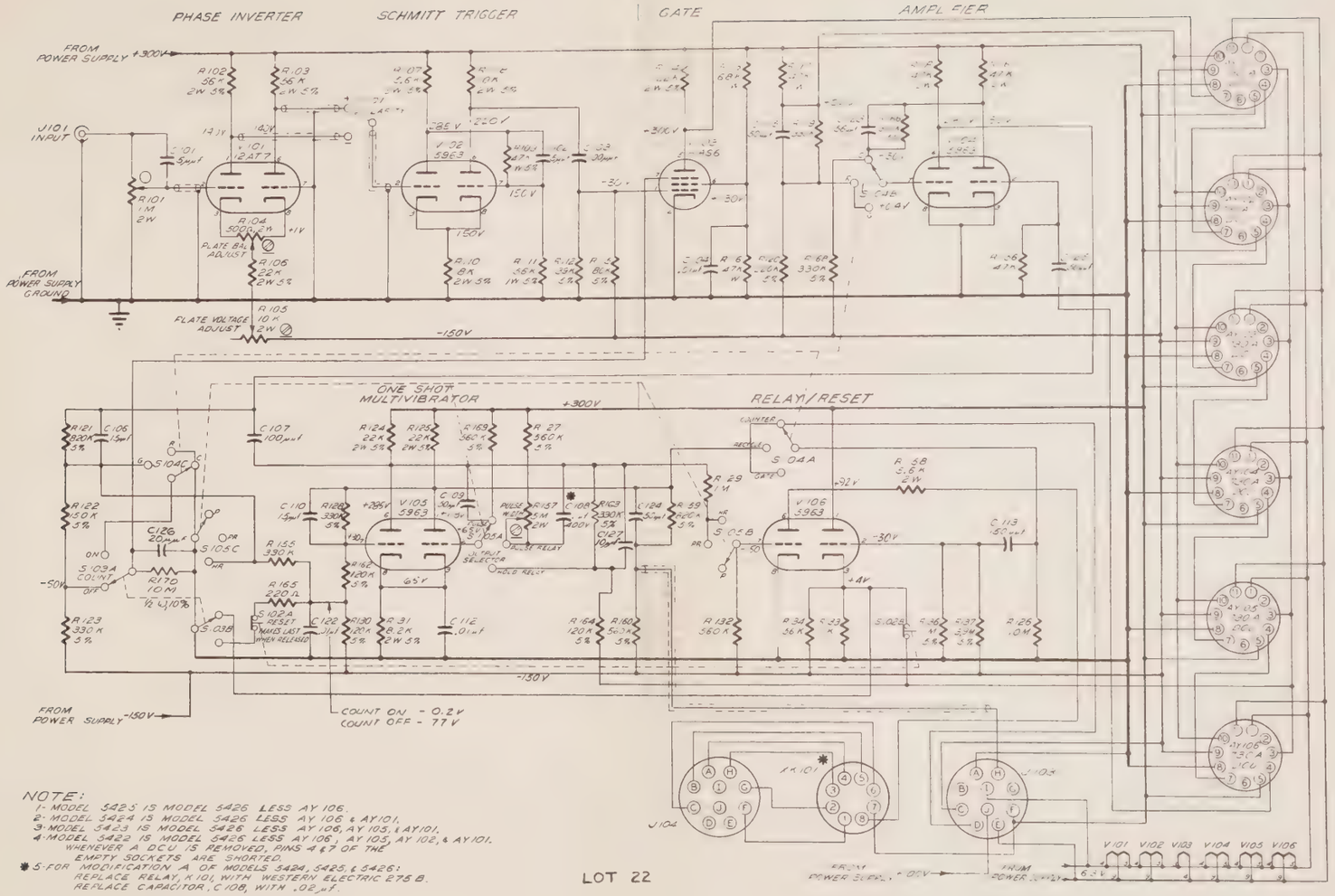


P. Cathode-follower output at pin 3 of V106 for preset count of 3. Amplitude, 80 volts rise time of 3 μsecs and a duration of 14 μsecs. Oscilloscope sweep time, 250 μsecs.



Q. DCU output, pin 4 of AY101, the units unit. Amplitude 80 volts. Oscilloscope sweep time, 250 μsecs.

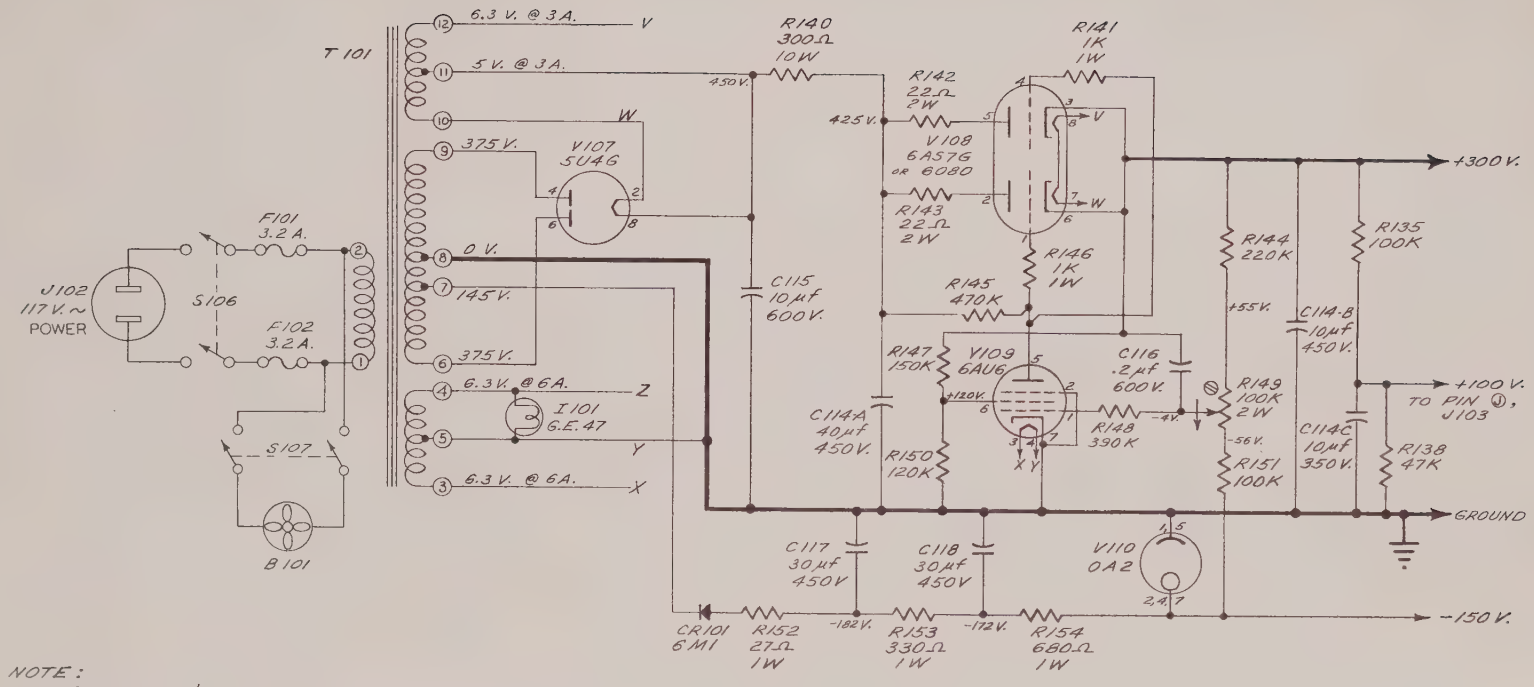
FIGURE 4C - PRESET COUNTER WAVEFORMS



NOTE:
1- MODEL 5425 IS MODEL 5426 LESS AY 106.
2- MODEL 5424 IS MODEL 5426 LESS AY 106 & AY 101.
3- MODEL 5423 IS MODEL 5426 LESS AY 106, AY 105, & AY 101.
4- MODEL 5422 IS MODEL 5426 LESS AY 106, AY 105, AY 102, & AY 101.
WHENEVER A DCU IS REMOVED, PINS 4 & 7 OF THE EMPTY SOCKETS ARE SHORTED.
* 5- FOR MODIFICATION A OF MODELS 5424, 5425, & 5426:
REPLACE RELAY, K 101, WITH WESTERN ELECTRIC 275 B.
REPLACE CAPACITOR, C 108, WITH .02 μf.

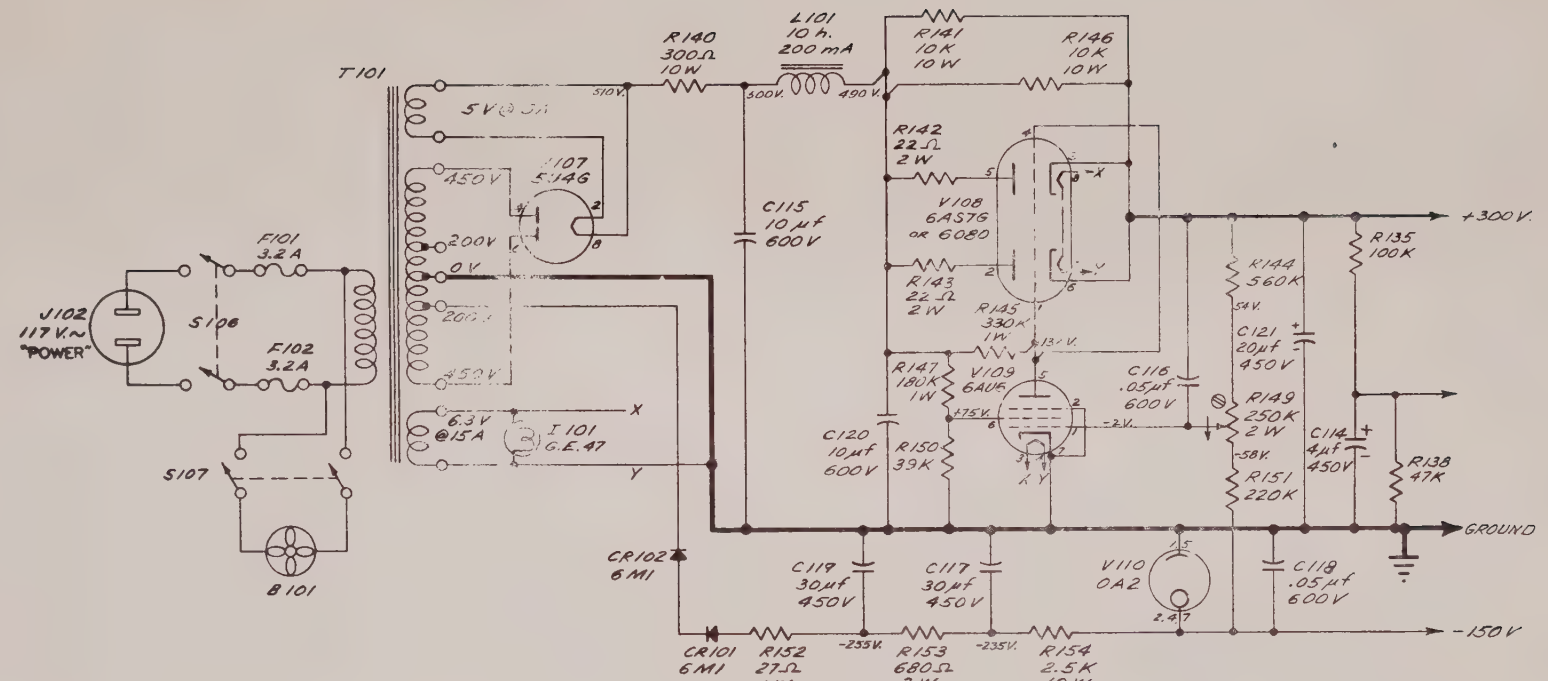
NOTE:
UNLESS OTHERWISE SPECIFIED:
ALL RESISTORS ½ W
ALL RESISTORS 10%
ALL CAPACITORS 300V.
ALL VOLTAGES MEASURED WITH A SENIOR VOLTOMYST AND WITH ALL DCU'S PRESET AND RESET AT ZERO.
WITH COUNT SWITCH ON

Figure 5 Schematic Diagram, Model 5422 -6



NOTE:
RESISTORS $\frac{1}{2}$W, 10% UNLESS OTHERWISE NOTED.

Figure 7 Schematic Diagram, Power Supply Models 5422-5423



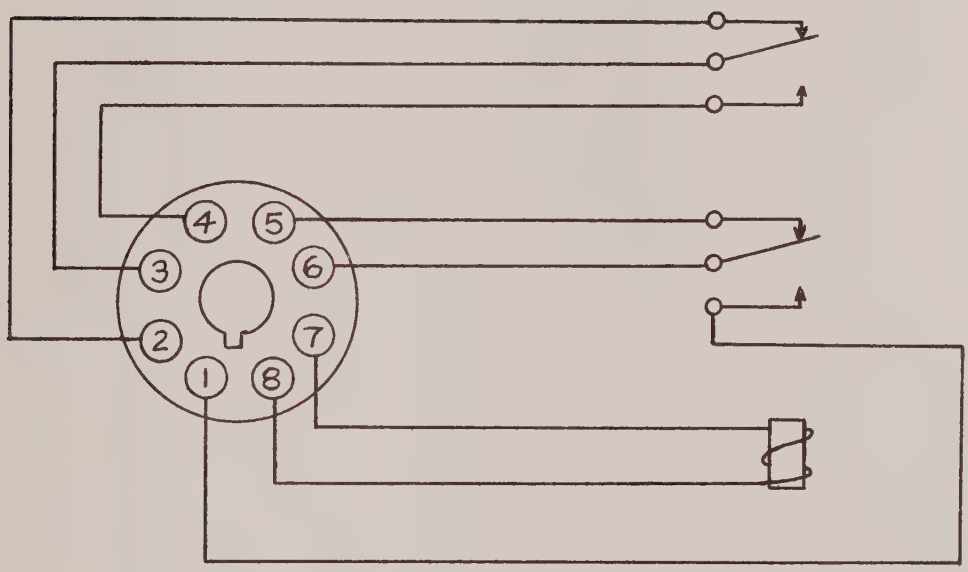
NOTE:

RESISTORS ½W, 10% UNLESS OTHERWISE NOTED.

ALL VOLTAGES MEASURED WITH RCA SENIOR VOLTOHMYST AND WITH ALL DCU'S PRESET AND RESET TO

(9-27-56)

Figure 8 Schematic Diagram, Power Supply Models 5424-5426



Relay shown in de-energized position; however in the Preset Counter the relay is energized until a particular preset count is reached.

FIGURE 9. RELAY K101, INTERNAL CONNECTIONS OF STANDARD RELAY

INSTRUCTION
MANUAL

Lot 10 and up

BERKELEY
PRESET DECIMAL COUNTING UNIT

Model 730A

BERKELEY division of
Beckman Instruments, Inc.

Richmond 4, California
8 April 1954

WARRANTY

Instruments sold by Berkeley Division, Beckman Instruments, Inc., (hereafter called "the Company") are warranted only as stated below.

Subject to the exceptions and upon the conditions specified below, the Company agrees to correct, either by repair, or, at its election, by replacement, any defect of material or workmanship which develops within one year after delivery of the instrument to the original purchaser by the Company or by an authorized representative, provided that investigation and factory inspection by the Company discloses that such defect developed under normal and proper use.

The exceptions and conditions mentioned above are the following:

(a) All instruments claimed defective must be returned to the Company, transportation charges prepaid, and will be returned to the customer with the transportation charges collect.

(b) The Company makes no warranty concerning components or accessories not manufactured by it, such as tubes, fuses, batteries, etc. However, in the event of the failure of any component or accessory not manufactured by the Company, the Company will give reasonable assistance to the purchaser in obtaining from the respective manufacturer whatever adjustment is reasonable in the light of the manufacturer's own warranty.

(c) The Company shall be released from all obligations under its warranty in the event repairs or modifications are made by persons other than its own service personnel or authorized representatives' personnel unless such repairs by others are made with the written consent of the Company.

(d) Except as stated above, the Company makes no warranty, express or implied (either in fact or by operation of law), statutory or otherwise; and, except to the extent stated above, the Company shall have no liability under any warranty, express or implied (either in fact or by operation of law), statutory or otherwise.

(e) The Company expressly disclaims any liability to its customers, dealers, and to users of its products, and to any other person or persons for consequential damages of any kind and from any cause whatsoever arising out of or in any way connected with the manufacture, sale, repair, replacement of, or arising out of or in any way connected with the use of any of its products.

(f) Representations and warranties made by any person, including representatives of the Company, which are inconsistent or in conflict with the terms of this warranty (including but not limited to the limitation of the liability of the Company as set forth above) shall not be binding upon the Company unless reduced to writing and approved by an officer of the Company.

(g) This warranty shall be governed by the laws of the State of California.

Claims for damage in shipment should be filed promptly with the transportation company.

All correspondence concerning the instrument should specify the model and serial number. This information appears on the company name plate. Any inquiry concerning details of operation, possible modifications, etc., should be addressed to the Sales Department, Berkeley division of Beckman Instruments, Inc., Richmond 4, California.

REPAIR SERVICE

Experienced service personnel and special test equipment are available at the factory to perform any necessary repairs. Every effort will be made to expedite the repair of instruments returned for servicing. Repair work will be performed only upon receipt of a written purchase order or authorization. Instruments to be repaired should be addressed to SERVICE AND REPAIR DEPARTMENT with transportation charges prepaid. Repaired instruments will be returned to the purchaser with transportation charges collect.

Berkeley reserves the right to make changes in design at any time without incurring any obligation to modify equipment previously purchased to conform to subsequent design changes.

BERKELEY DIVISION
BECKMAN INSTRUMENTS, INC.

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Berkeley division
BECKMAN INSTRUMENTS, INC

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SPECIFICATIONS

Count Indication	Direct reading decimal presentation
Power Requirements	Heater: 6.3 v. at 2.1 amps. 300 v. at 18 ma. -150 v. at 1 ma.
Input Requirements recommended	Negative pulse 90 volts peak amplitude.
Rise Time	1 μsecond.
Duration	At least 2 μseconds.
Counter Output Characteristics.	Designed to drive another Model 730A.
Coincidence Amplifier Output	200 volt positive transient.
Reset	Manual or electronic (see Section 3, Operation).
Resolution or Paired Pulses	5 μseconds.
Maximum Counting Rate	40,000 cps for single unit.
Construction	Plug-in unit for 11-pin socket.
Dimensions:	2-1/2" x 5-1/2" x 6-1/2".
Weight:	1 lb. 7 oz.
Tubes:	4 ea. 5963; 2 ea. 5964.

Section 1

INTRODUCTION

The Berkeley Preset Decimal Counting Unit, Model 730A is a high-speed electronic counter combined with a coicidence amplifier. The unit is designed to emit an output signal for any required number of counts from one to ten as determined by depressing one of the ten numbered pushbuttons on the front panel. When the "0" pushbutton is depressed, the instrument will function as a conventional decimal counter, counting from zero to nine, the tenth pulse resetting the unit to zero and at the same time generating an output signal. When some pushbutton other than "0" is depressed, the coincidence amplifier will deliver an output signal when the counter has received the required number of counts. By making use of the coincidence amplifier output to reset the unit (see Section 3), the Model 730A can be used as a counter with a variable scaling factor of any number from one to nine. This method of reset may also be used when the unit counts or measures quantities such as numbers of objects and periods of time. The number of counts received is indicated by the illumination of one of ten neon lamps placed behind a numbered acetate panel.

Any number of these units can be connected in cascade (the output of one unit driving the next), thereby making a preset counter whose total count capacity will be dependent only on the number of Model 730A units. Thus five units will count and reset for any number from one to 100, 000.

The maximum counting rate is 40, 000 cycles per second with a resolution time of 5 microseconds.

Section 2

THEORY OF OPERATION

Counter Circuit Analysis

The basic circuit of the counter section of the Model 730A is a modification of the Eccles-Jordan trigger circuit with two stable states, known as a binary. The binary is a two-stage amplifier with the output of the second stage connected to the input of the first, as shown in Figure 1.

With no input, the loop gain is less than one, and the circuit is in one of its two stable states, i.e., either V2 conducting and V1 cut off, or vice-versa. The circuit is triggered from one state to the other by making the loop gain greater than one. The binary is coupled to a single trigger source through C1 and R1 in such a way that the effect of the trigger is different on the two stages, depending on which stage is conducting. For example, assume that V2 is conducting and V1 is cutoff. If a negative pulse is applied to the input, there is a drop in the plate voltage of V1. This drop in voltage is transmitted through the cross-over network (R5, R8, C3, and the grid-to-ground capacitance of V2) and applied to the grid of V2. The plate voltage of V2 then starts to rise, carrying with it the grid of V1. When the input pulse is of sufficient amplitude, the loop gain becomes greater than one, and the binary is triggered to its other stable state, V1 conducting and V2 cut off. The next input pulse reverses the process and causes the binary to return to its original state. Thus, the binary completes a cycle for every two input triggers and is a scale of two. By a cascade arrangement of binaries, a counter having a scale of any power of two can be obtained.

In the Model 730A, four binaries are connected in cascade, forming a scale of sixteen which is permuted to a scale of ten by two resistor-capacitor "feedback" networks (see Figure 2).

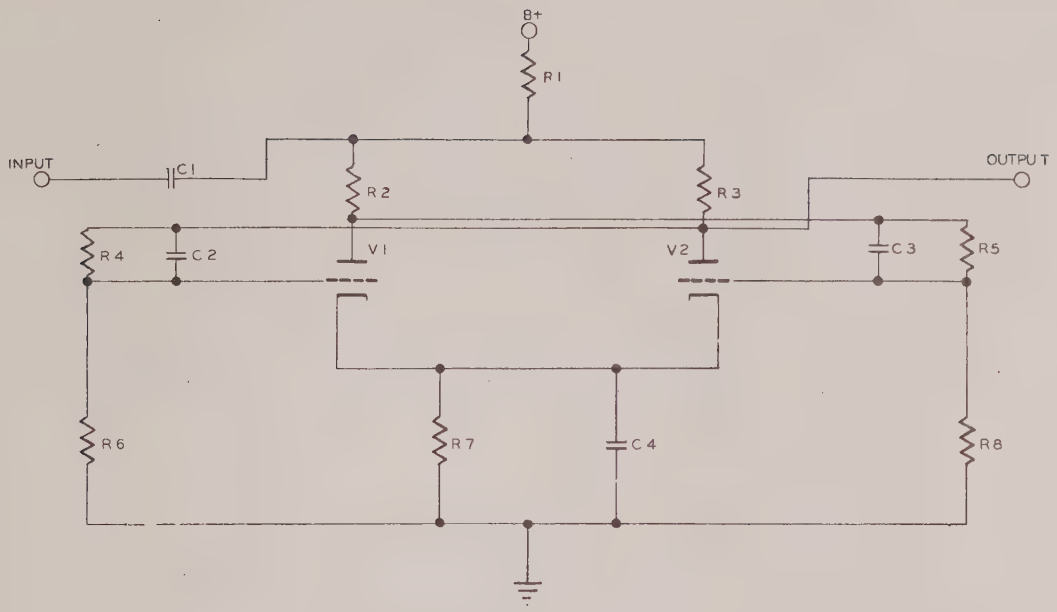


Figure 2 Basic Circuit

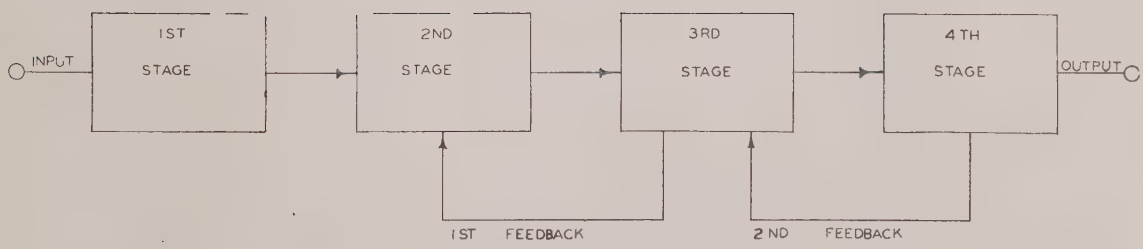


Figure 3 Functional Diagram

The circuit operates as a conventional binary counter up to the count of four. On the count of four the third stage is triggered, sending a pulse through the first feedback network, thereby triggering the second stage. Since it requires two inputs to trigger the second stage, this is the equivalent of adding two input pulses and the unit now corresponds to a binary count of six. On the count of six (which is the equivalent of eight in a binary counter) the fourth stage is triggered, sending a pulse through the second "feedback" network and triggering the third stage. This is the same result as if four additional input pulses had been applied and the unit has a binary count of twelve stored in it. The unit again operates as a binary scaler for the remaining four pulses required to reset it to zero. Therefore, by adding the equivalent of six input pulses, the scale of sixteen has been permuted into a scale of ten.

Coincidence Circuit Analysis

The coincidence amplifier (see Figure 6) consists of four triodes (two 5964's), twelve resisors (R149 through R160) and a 10-pole pushbutton switch.

Four resistor-dividers are connected between four of the plates of the counting unit and -150 volts. The division ratio is such that if the resistor connected to the -150 volts is shorted, its tube will be cut off at all times. However, if this short is removed, the division ratio is such that the tube follows the plate of the binary to which it is connected, i e , if the short around R157 is opened, V105 will be turned on and off, depending on the state of the first binary, V101. Since the plates as well as the cathodes of V105 and V106 are connected together, coincidence is obtained when all four tubes are at plate current cut-off.

The number to be preset is selected by pushing one of ten buttons on a switch. The #4 button opens switch S104, the #5 button opens switch S105, and etc.

When any number other than zero is selected and the unit is reset to zero, at least one coincidence triode will be conducting. As the count progresses, the number of tubes conducting varies in such a way that when the preset number is reached, all the triodes are cut off and a

large positive transient is obtained at the output of the coincidence amplifier. This information is used either to reset the unit to zero through a cathode follower reset circuit, or to gate off the input pulses.

Section 3

OPERATION

Installation

Normally, the Model 730A DCU is installed as a plug-in unit in a Berkeley instrument. No special instructions are necessary. For information concerning unusual installations, we invite your inquiry.

Operation

Power requirements:

Plates- - - - - - - - 300 volts at 19 ma.
Filaments- - - - - 6.3 volts at 2.1 amps.
Bias- - - - - - - - - 150 volts at 1 ma.

Input requirements:

Counter circuit - - When the unit is powered by an unregulated supply the drive amplitude should vary with the supply voltage. A negative transient is required to drive the unit. It can be either a square wave, or a rectangular pulse which is at least 2 μseconds wide. The pulse amplitude in either case is dependent upon the rise time. For a rise time of 0.5 μseconds (measured between the 10 and 90 per cent values), the pulse amplitude should be between 75 and 135 volts, while for a rise time of 2 μseconds, the amplitude should be between 120 and 165 volts. The recommended values are 1 μsecond rise time and 100 volts amplitude for a 300 volt supply.

DCU input load - - The load at triggering is equivalent to 100 $\mu\mu$f in series with 15K.

Reset circuitry - - By using the circuit shown in Figure 5, the unit can be electronically or manually reset. Other circuits may also be used, provided a positive pulse of the correct amplitude, width and rise time is applied to the reset pin (pin #3 of the 11-pin plug) of the Model 730A. The required pulse amplitude is dependent upon

its rise time and the number of units being reset. The recommended values for one unit are : 3 μseconds rise time, 15 μseconds pulse width, and 70 volts amplitude.

If electronic reset is not required, the reset pin should be connected to ground through a normally closed switch or relay contacts. To reset the unit, the contacts are opened momentarily. Care must be taken to avoid coupling the voltage surges into the input or power supply circuits.

Output requirements:

Counter circuit -- The output is a rectangular waveform presented at the output terminal as a change in d-c voltage (see fourth stage, Figure 3). On the counts from "0" to "5", its value is 55 volts. For the counts "6" and "7", it is 127 volts, while for "8" and "9", it is 135 volts. The step between "7" and "8" is due to the effect of the interpolation network. The load imposed on the unit must not be more than 300, 000 ohms to ground, or a 6, 000 ohm resistor in series with 100 $\mu\mu$f.

Coincidence amplifier circuit -- A plate load resistor for the coincidence amplifier must be connected between pins 5 and 10 of the 11-pin plug. This resistor should be large (about 47K) compared to the plate resistance of any one of the tubes when it is conducting. Connected in cascade, pin 10 of each DCU should be shorted to the other units. Output waveforms (pin 10) are shown for each position of the preset switch in Figure 4.

Section 4

MAINTENANCE

General

When a Preset Decimal Counting Unit is suspected of counting incorrectly, it should be interchanged with another unit in the instrument or replaced with a spare unit to determine whether the trouble is in the suspected unit or in the associated circuitry. This test should be made very carefully. The counting unit is usually the indicating device of an instrument and is quite often accused of counting incorrectly when the fault is external to it.

NOTE

Before attempting to trouble-shoot this counter circuit, V105 and V106 should be removed from their sockets.

Counter Circuit Troubleshooting

Two methods are recommended for finding the trouble in a faulty counting circuit; first, observe the lighting sequence while driving the unit at a slow repetition rate; and second, observe the waveform of each stage on an oscilloscope at a rate high enough for convenient viewing. It is impossible to say which method should be used in every case. Since marginal failures may occur at high counting speeds and not at lower counting rates, and vice versa. The first method is the only way that a neon lamp failure can be located, and it can be used to locate component and tube failures. For this reason, it is recommended that this method be used first. Table 1 lists common troubles and their causes. When a stage is indicated to be at fault, the trouble usually is the tube.

Table 1

COMMON TROUBLES AND THEIR CAUSES*

SYMPTOM	CAUSE
Unit Fails to Count	(a) Insufficient supply voltage. (b) Input signal of insufficient amplitude. (c) Input signal of wrong polarity. (d) First stage inoperative.
Unit Counts Spuriously	(a) Stray output signal. (b) Pulses received through power supply. (c) External voltages picked up by output lead.
Unit Counts Erratically	(a) Input signal too large or small, incorrect rise time. (b) Supply voltage fluctuating too much.
Unit Fails to Reset	(a) Stray counts from reset switch or associated circuitry. (b) Defective component.
Unit Counts in Wrong Sequence (the pattern of lighting is repeated after a definite number of input pulses. One or more lights may be "On" simultaneously during a cycle provided that the number of states per cycle remains constant).	
1. Unit skips every other number.	(a) First stage defective. (b) Input circuit supplies double pulses.
2. Two stable states per cycle.	(a) Second stage defective (count can be 01 or 45). (b) Loss of drive to second stage (01).
3. Four stable states per cycle.	(a) Third stage defective (count can be 0123 or 6789). (b) Loss of drive to third stage (0123).

4. Six stable states per cycle.	(a)	Output excessively loaded (count can be 012345-012345).
	(b)	Last stage inoperative (count can be $01234\overset{5}{8}01$ etc. or $67\overset{89}{23}89$. The count 2 indicates both "8" and "2" lamps are on.
	(c)	Loss of drive to fourth stage (count can be 012345).
5. Eight stable states per cycle or any failure where two successive failures are skipped.	(a)	Second or third stage failure.
6. Ten stable states per cycle, but the lighting sequence is incorrect.	(a)	Where the "0" neon lamp lights instead of the "4" the trouble is with either the "0" or "4" lamp, and in the majority of cases it is "4". This can happen on any count; zero and four were used as examples. It is also possible that more than one lamp may light in place of or with the one that fails.
7. Twelve stable states per cycle.	(a)	When lighting sequence is $0123\overset{01}{45}456789$-0, etc. (the count $\overset{0}{4}$ indicates both "0" and "4" lamps are on). First feedback failure. Second or third stage losing emission.
	(b)	When the lighting sequence is 012345678989-0, etc. Second feedback failure. Third or fourth stage losing emission.

*Reset Unit before troubleshooting

Troubleshooting the Coincidence Amplifier and Preset Switch

If one of the coincidence amplifier tubes fails, the preset output may not occur on the count corresponding to the pushbutton depressed. The following table shows the count on which the coincidence output is obtained when one of the two tubes is out of the socket:

Number Preset	Count on which coincidence is obtained when V105 is out	V106 is out
0	No output	No output
1	No output	1
2	No output	2
3	No output	3
4	44	No output
5	4	1
6	6	No output
7	6	1
8	6	2
9	6	3

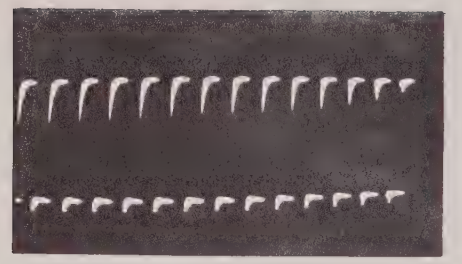
Any failure that is not remedied by replacing V105 and V106 with good tubes is probably due to malfunction of the switch stacks. Make sure that there is no dirt in the contacts and that they are normally closed, opening only when a button is depressed.

Diagrams and Tables

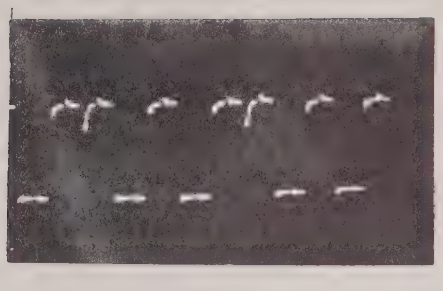
Figure 3 shows the idealized waveforms of each stage when the counting circuit is working properly. A study of these and the corresponding ones of a faulty unit will help in locating component and tube failures. The spikes at the count of "4" on the second stage and at "6" on the third stage are caused by the first and second feedbacks, respectively. Figure 5 shows the output waveforms of the coincidence amplifier with a 47K resistor between pins 5 and 10. Circuit drawings and parts location diagrams will be found at the rear of the manual. The voltages shown were

Table 2
MODEL 730A - VOLTAGES & RESISTANCES

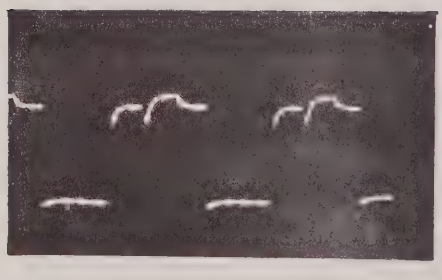
Tube	Pin No.	D. C. Voltage to Ground	Resistance to Ground (in ohms)
V101	1	170	105K
	2	17	85K
	3, 8	37	12K
	4, 5, 9	Filaments	
	6	60	105K
	7	37	85K
V102	1	135	93K
	2	15	83K
	3, 8	30	12K
	4, 5, 9	Filaments	
	6	55	93K
	7	30	83K
V103	1	135	100K
	2	15	83K
	3, 8	30	12K
	4, 5, 9	Filaments	
	6	55	100K
	7	30	83K
V104	1	135	93K
	2	15	83K
	3, 8	30	12K
	4, 5, 9	Filaments	
	6	55	93K
	7	30	83K
V105	1, 2	300	140K
	3, 4	Filaments	
	5	-25	500K
	6	-20	500K
	7	0	0
V106	1, 2	300	140K
	3, 4	Filaments	
	5, 6	-25	500K
	7	0	0



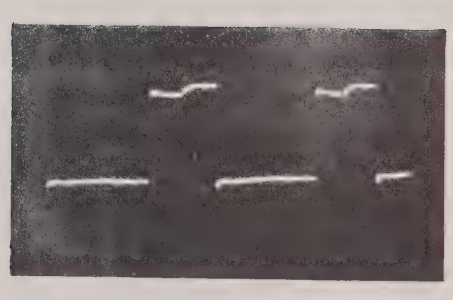
A. First Stage, Pin 6, V101, UVL + 168, LVL + 58, frequency 20Kc.



B. Second Stage, Pin 6, V102, UVL + 140, LVL + 55, frequency 20 Kc.

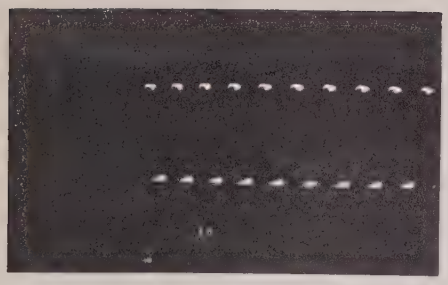


C. Third Stage, Pin 6, V103, UVL + 140, LVL + 55, frequency 20 Kc.

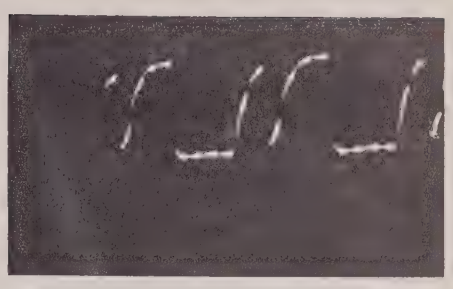


D. Fourth Stage, Pin 6, V104, UVL + 140, LVL + 55, frequency 20Kc.

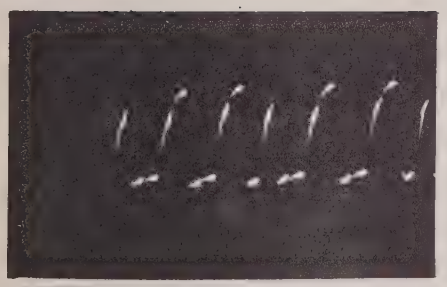
Figure 3 Typical Waveshapes



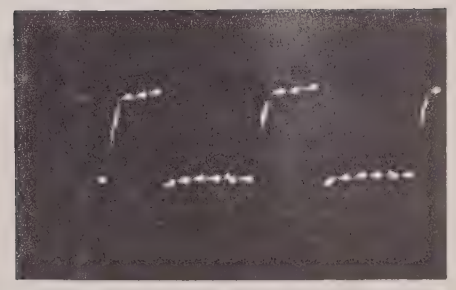
E. First Stage, Pin 6, V101, UVL + 168, LVL + 58, frequency 100Kc.



F. Second Stage, Pin 6, V102, UVL 140, LVL + 55, frequency 100Kc.

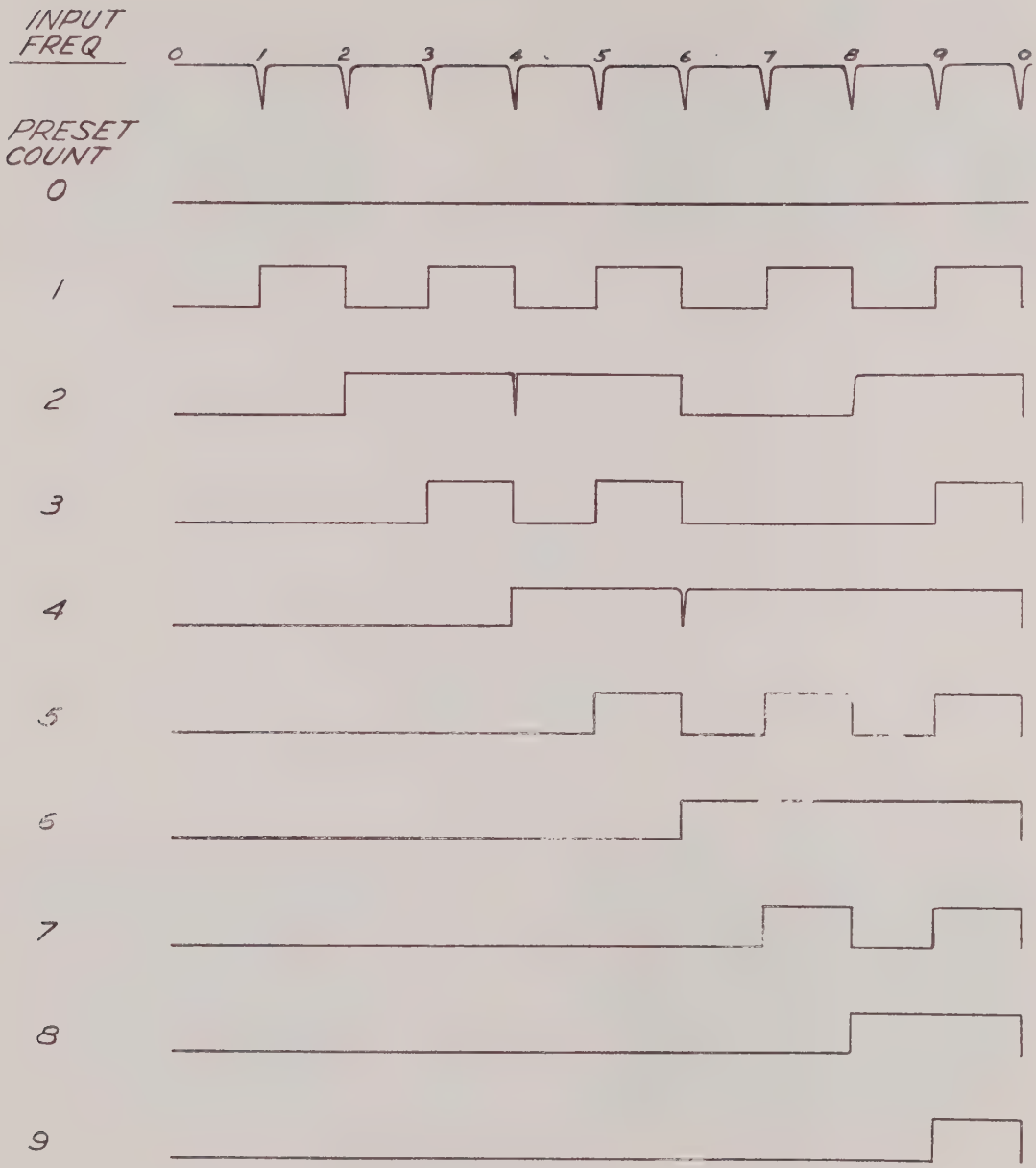


G. Third Stage, Pin 6, V103, UVL + 140, LVL + 55, frequency 100Kc.



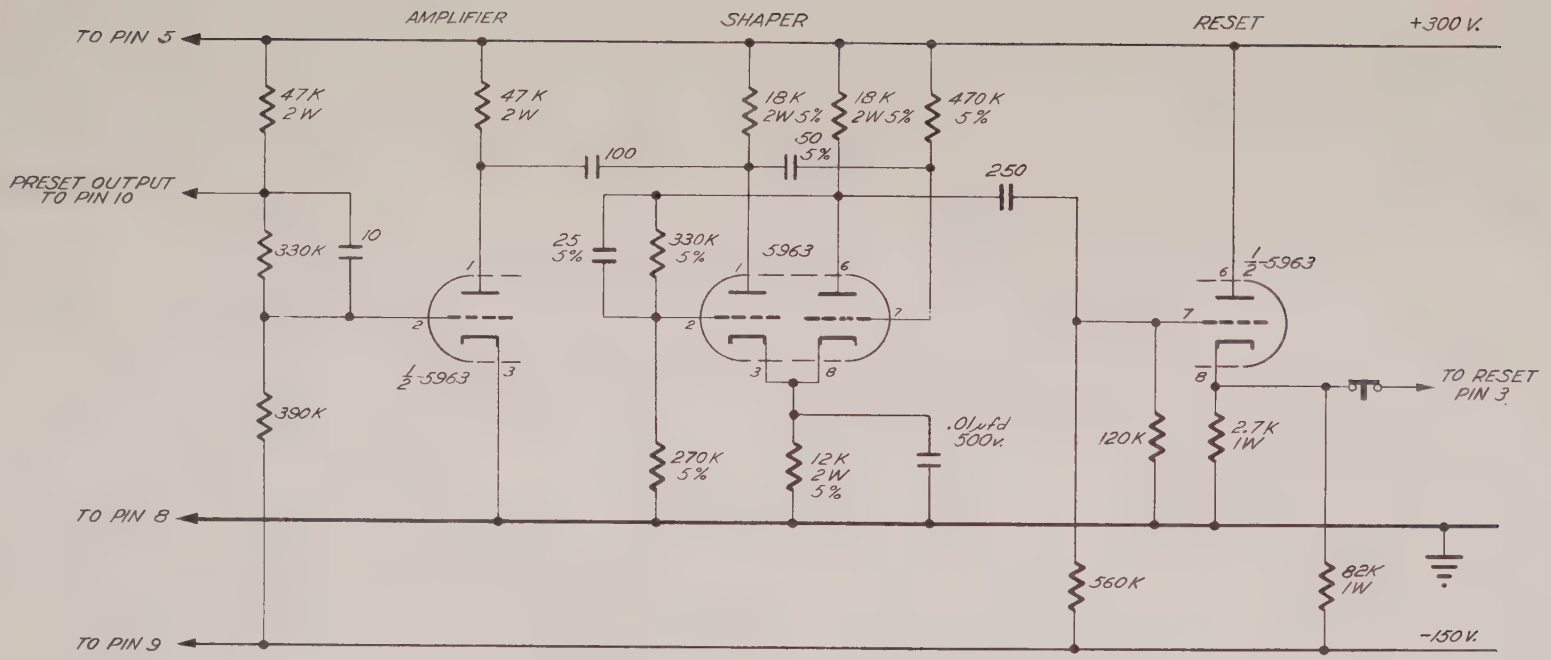
H. Fourth Stage, Pin 6, V104, UVL + 140, LVL + 55, frequency 100 Kc.

Note: UVL = upper voltage level
LVL = lower voltage level
All waveforms are blanked.



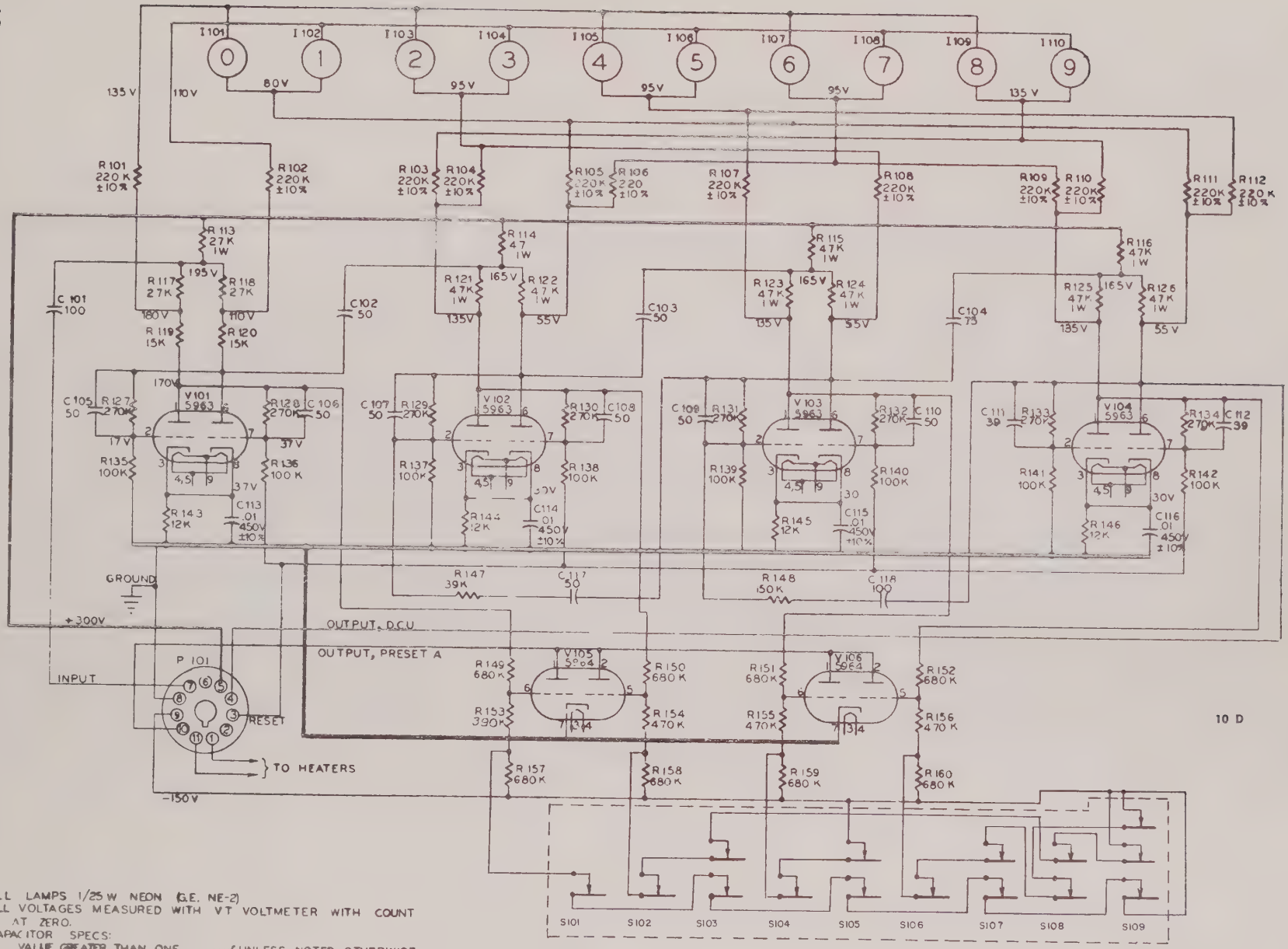
Note:
To obtain the above waveforms do not couple the preset output to the reset pin.

Figure 4 Coincidence Amplifier Plate Waveforms



NOTE:
1. ALL CAPACITORS IN µµf.
2. ALL RESISTORS ½W, 10% UNLESS OTHERWISE NOTED.

Figure 5 Recommended Reset Circuit For Model 730A



ALL LAMPS 1/25 W NEON (G.E. NE-2)
ALL VOLTAGES MEASURED WITH VT VOLTMETER WITH COUNT AT ZERO.
CAPACITOR SPECS:
VALUE GREATER THAN ONE ____ μμf UNLESS NOTED OTHERWISE
VALUE LESS THAN ONE ____ μf " " "
TOLERANCE ____ ±5% " " "
VOLTAGE RATING ____ 500 V " "
RESISTOR SPECS:
POWER RATING ____ W "
TOLERANCE ____ ±5% " "

Figure 6 Schematic Diagram, Model 730A Decimal Counting Unit

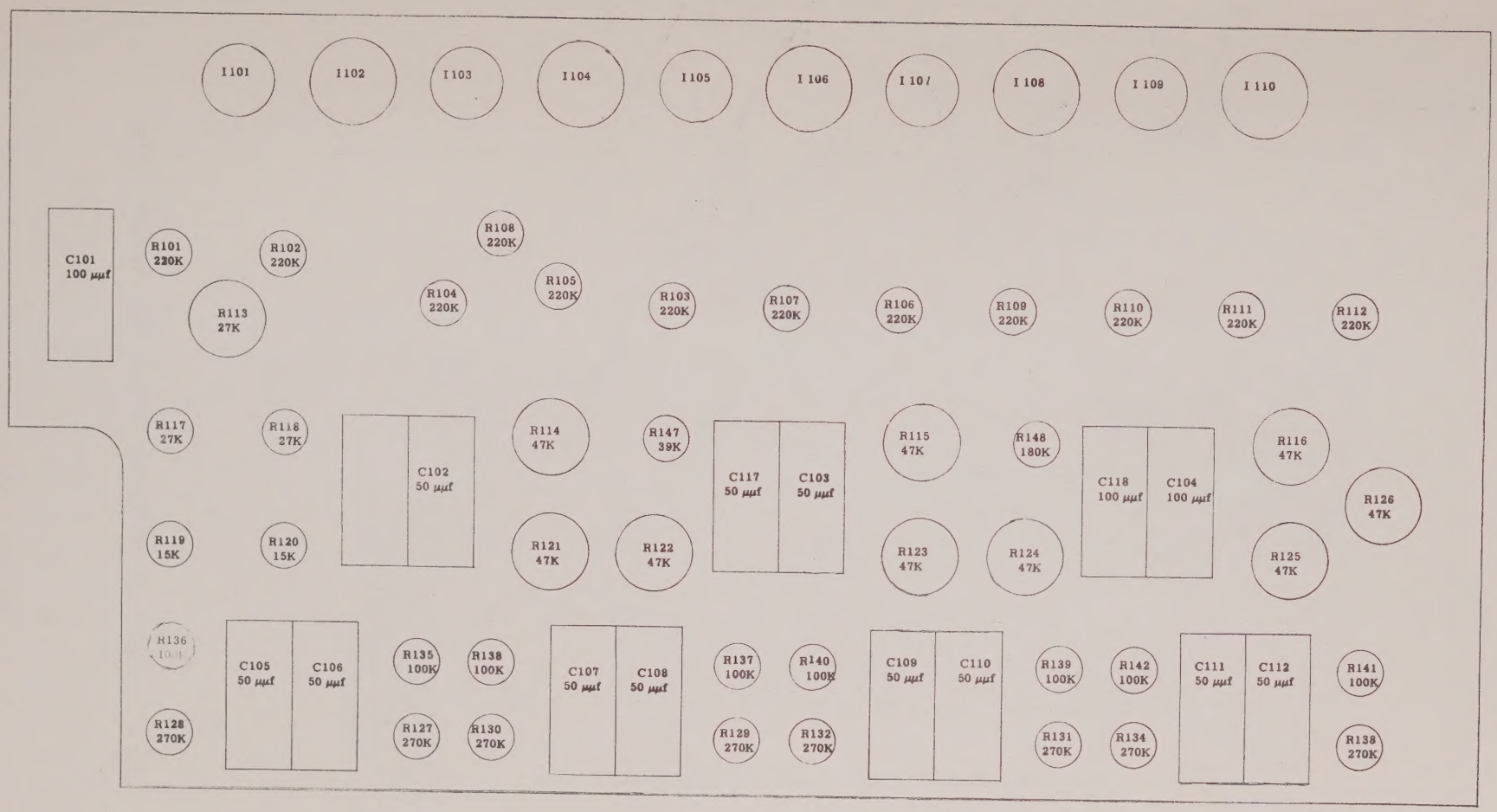
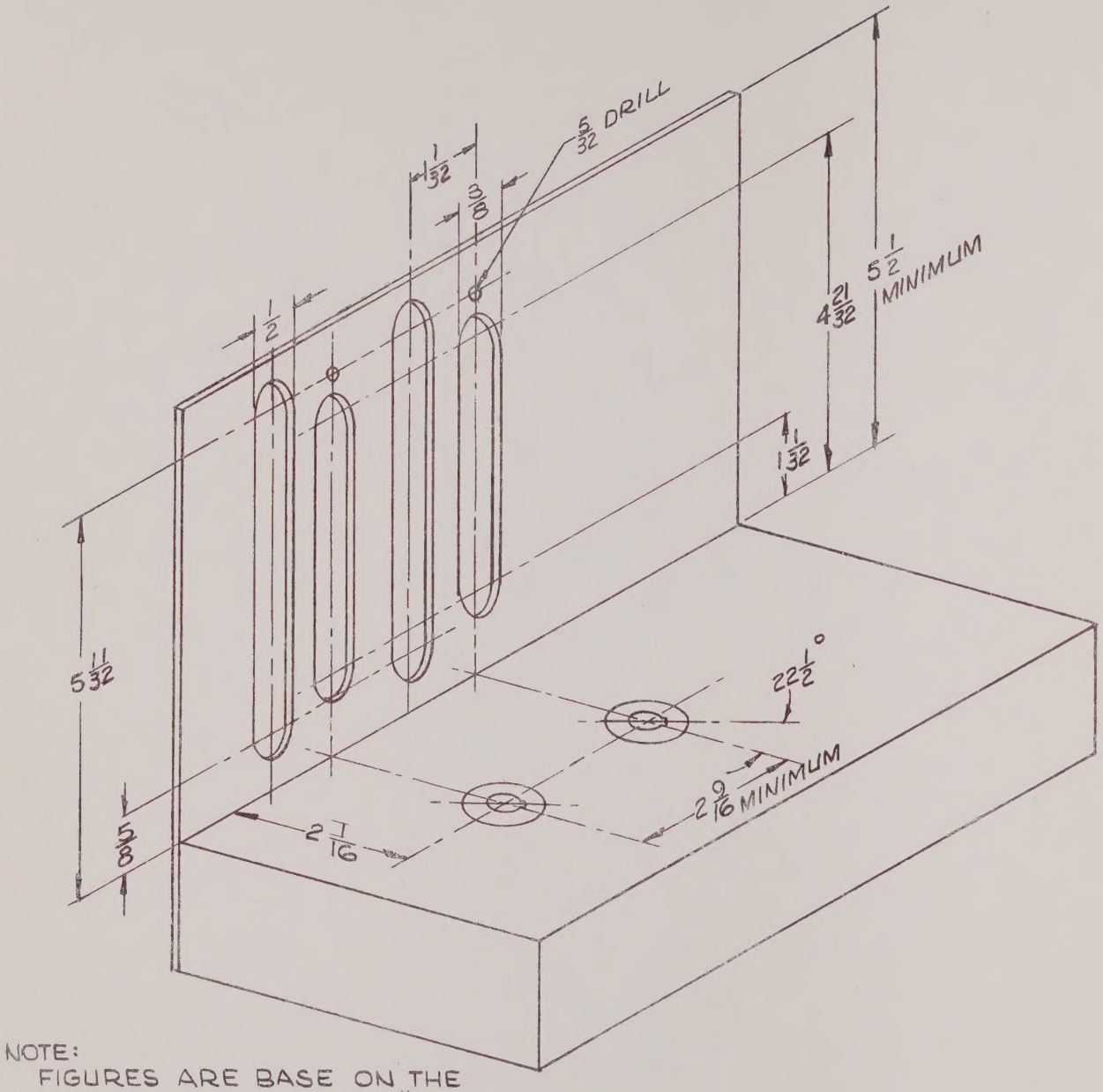


Figure 7 Parts Layout



NOTE:
FIGURES ARE BASE ON THE USE OF AMPHENOL "MIP" SOCKETS AND .064 METAL FOR THE CHASSIS.

Figure 8 Mounting Dimensions, Model 730A